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Washington, D. C. PROFESSIONAL PAPER January 18, 1921

THE MAINE SARDINE INDUSTRY

By

F. C. WEBER
Chemist in Charge
With the collaboration of H. W. HOUGHTON and J. B. WILSON
Assistant Chemists, Animal Physiological Chemical Laboratory

CONTENTS

Page

Introduction:

The Sardine 1
The Maine Sardine Industry . . . 3
The Maine Sardine 4
Food Value of the Canned Sardine . 5
Purpose of Investigation. 6
Methods Employed in Packing Sardines 6

Experimental Work:

Methods of Analysis 12
Composition of the Sea Herring . . 15
Food of the Sea Herring 17
Swells 20
Transportation of the Fish 26
Pickling and Salting the Fish . . . 34
Flaking the Fish 50
Drying the Fish 51

Page

Experimental Work—Continued.

Packing the Fish 58
Adding the Oil 60
Processing the Sardines 69
Storing the Sardines 70
Decomposition of the Fish 86
Grading the Fish 93
Standardization of the Sardine Pack . . . 96
Sanitary Precautions in Packing Sardines 98

Waste in Packing Sardines:

Elimination of Unnecessary Waste . 102
Utilization of Unavoidable Waste . . 109
Economic Considerations 115
Summary 121
Bibliography 125

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CONTENTS.

Introduction: Page.

The sardine 1
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Food value of the canned sardine 5
Purpose of investigation 6
Methods employed in packing sardines 6

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Methods of analysis 12
Composition of the sea herring 15
Food of the sea herring 17
Swells 20
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Adding the oil 60
Processing the sardines 69
Storing the sardines 70
Decomposition of the fish 86
Grading the fish 93
Standardization of the sardine pack 96
Sanitary precautions in packing sardines 98

Waste in packing sardines:

Elimination of unnecessary waste 102
Utilization of unavoidable waste 109
Economic considerations 115
Summary 121
Bibliography 125

INTRODUCTION.

THE SARDINE.

The sardine, popularly regarded as a particular species of fish used for canning, derives its name from the island of Sardinia, in the Mediterranean Sea, where the fish from which the sardines of that region are made abound (27).[1] The term "sardine" is now applied in this country to the small fish of the Clupea family, numerous species of which are canned as sardines in various parts of the world.[2] The pilchard (*Clupea pilchardus*) is the fish used in the French sardine industry, and the brisling or sprat (*Clupea sprattus*) in the Norwegian industry. The California sardine (*Clupea coeru-*

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[1] The figures in parentheses refer to the bibliography at the end of this bulletin.

[2] Food Inspection Decision 64, issued by the U. S. Department of Agriculture, March 29, 1907, provides that the labels of the canned sardines shall state the country or locality from which the fish are packed, as an indication of the species.

leus), closely resembling the French species, is canned on the Pacific coast of the United States, while the immature sea herring (*Clupea harengus*) is put up on the eastern coast as the Maine sardine.

The Bureau of Fisheries of the United States Department of Commerce states that the herring may be distinguished readily from the pilchard before it is cleaned and canned, the following points of difference being submitted:

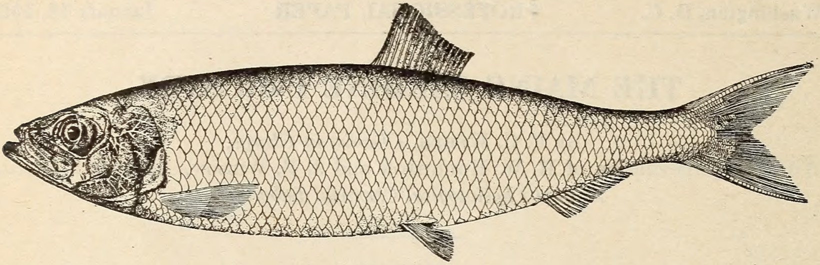

FIG. 1.—The herring.

The lower jaw of the herring (figure 1) projects a little beyond the tip of the snout when the mouth is closed; the gill covers are smooth; the fish is more or less compressed from side to side; and the belly rather sharp-edged. If the fish were cut in two, crosswise, the cross section would be somewhat egg-shaped. The fin on the back is situated nearer the base of the tail than the tip of the snout. The scales are comparatively small and have rounded edges. When the scales are removed no series of dusky spots is observable.

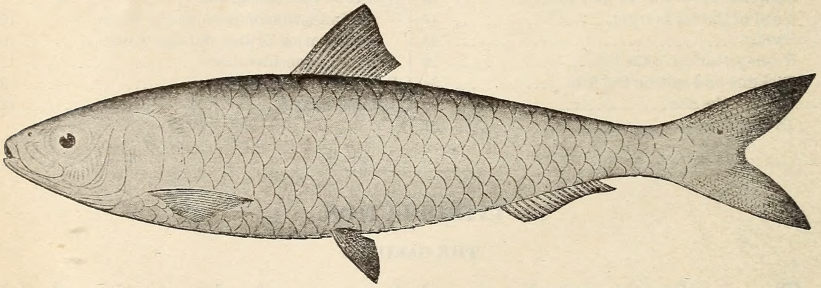

FIG. 2.—The pilchard.

The lower jaw of the pilchard (figure 2) projects but slightly, if at all, beyond the tip of the snout when the mouth is closed. Sharply-defined, fine ridges run downward and backward across the gill cover. The fish is more cylindrical than the herring, and a cross section would present a circular rather than an oval outline. The fin on the back is situated nearer the tip of the snout than the base of the tail. The scales are comparatively large, twice as large as those of the herring, and show a more or less angular outline of the edge. When the scales are removed a series of several dusky spots along the side of the front part of the body is usually plainly discernible.

To open a can of sardines of unknown origin and attempt to determine whether the fish is a herring or a pilchard presents a greater difficulty. Since the heads of both kinds are removed in the canning process, the jaw and gill cover characteristics can not be observed. The scales of both fish are easily detached and may not be present in the can. The absence of the head prevents ascertaining the position of the back fin in relation to the tip of the snout.

As the skin of the herring is thinner than that of the pilchard, it more quickly loses its silvery appearance, particularly after the loss of its scales and subjection to the cooking process. In consequence, a dull-colored, laterally flattened fish with the edge of the belly somewhat sharp-edged would suggest a herring. If the distance from the front of the base of the back fin directly to the belly, when applied twice to the distance from the rear of the base of the back fin to the middle of the base of the tail, extends beyond the base of the tail fin, it is almost positively a herring. If fine, round-edged scales are present, the diagnosis is quite positive.

On the other hand, the French sardine (pilchard), having a thick skin, has a tendency to retain much of its silvery appearance, even after being cooked, and this silveriness is more or less sharply defined from the bluish back. A silvery, plump fish with a rounded belly indicates a pilchard. If the dimension for the width of the fish, applied from the back fin to the base of the tail in the manner described, does not reach to the base of the tail, the fish is quite positively a pilchard. If conspicuous scales, with one end angular, are present, the fish positively is a pilchard; also if a series of dusky spots is observed along the side forward.

THE MAINE SARDINE INDUSTRY.

Sardines(27) have been canned in Europe since 1834, and the imported product has long been a popular article of food in this country. When the Franco-Prussian War cut off our supply of sardines from abroad, an opportunity was presented for the beginning of an American industry. It was not until 1876, however, that the first successful plant for canning sardines was established in Eastport, Me., by Julius Wolff, of the New York firm of Wolff & Reesing. Additional canneries were soon built in the vicinity of Eastport and Lubec, and at other points along the Maine coast.

In the early days of the industry it was possible to enter the business with a very small capital, as all the work was done by hand and no expensive machinery was needed. Practically the only large outlay required was for the materials used in making the cans and for oil. In many cases these supplies were advanced by the dealers in tin plate or by the commission merchants, who later accepted canned sardines in payment. Thus the packer was relieved, to a certain extent, of responsibility for the quality of his goods, and a tendency to sacrifice quality for quantity in the pack was developed. So large a number of individual canneries operated during the period from 1877 to 1899 that the business became most unprofitable. This condition resulted in an unsuccessful attempt to form a combination about 1899. A little later two large companies were organized, one of which built a factory for machine-made, machine-sealed cans, to replace the three-piece, handmade, soldered cans originally employed. These two firms soon consolidated, and two years later sold out. The general dissension which developed in the sardine industry during these two years was a factor in inducing the original packers to reenter the business on an independent basis. New factories were built and new men came into the industry.

In 1903 machine-made and machine-sealed cans, upon which experiments had been made previously, were generally substituted for the three-piece, handmade, soldered cans originally used, and an independent company undertook to supply the cans. As a result, the quantity of fish packed increased markedly. In 1899, when handmade and hand-sealed cans were in use, the total pack of sardines amounted to 44,951,244 pounds, valued at $4,212,351. In 1904, just after the machine-made, machine-sealed cans had been introduced, the total quantity packed was 87,224,524 pounds, worth $4,380,498. In 1909, 90,694,284 pounds, valued at $4,931,831, were put up in the sardine canneries(33). In 1914 the value of the entire pack was $6,238,933(34). It is interesting to note that while the total quantity of sardines packed in either 1904 or 1909 was approximately double that packed in 1899, the total value was practically the same for all three years.

Several factors have led those engaged in the sardine industry to strive for a large output, often with a tendency to sacrifice quality. In fact, the majority of the improvements which from time to time have been adopted have been designed to increase the quantity of the pack rather than to improve its quality. At first, the sardines canned in this country were fried and packed in olive oil, and compared favorably with the foreign article. At one time the American sardine was sold on the market as the foreign product, which deception, however, was soon detected by the trade, and the dealers were forced to sell the domestic article on its own merits. But with the increasing production and increasing competition the price which the goods commanded declined, until it became necessary to pack the sardines more cheaply, resulting in the appearance on the market of a product vastly inferior to that sold during the first few seasons of the American industry. About 1880 the practice of using cottonseed oil instead of olive oil was introduced, and some 10 years later the excellent custom of frying the fish in oil gave way to the modern method of cooking the fish in live steam. Several companies, however, still fry the fish in oil.

THE MAINE SARDINE.

As it now enters the channels of trade, the Maine sardine is packed either in oil or in mustard or some other sauce, in cans of varying sizes, known as quarter oil, high-quarter oil, half oil, quarter mustard, and three-quarter mustard (p. 11). At the close of the investigation here reported, owing to the difficulty of importing foreign sardines and the increased prices the domestic brands could command, from 50,000 to 60,000 cases of sardines in olive oil were put up per annum by some 12 or 15 canneries. As a rule, cottonseed oil is used for packing sardines, the grade called prime summer yellow being most commonly employed, although several packers use the better grade known as winter-pressed oil, which they sometimes flavor with cloves, spice, or bay leaf, and a small amount of essential oil for the fancy or extra fancy grades.

Small quantities of Maine sardines are packed in tomato sauce, but a market for this article has not yet become widely established. Both the key-opening and the keyless type of cans are employed for this purpose.

FOOD VALUE OF THE CANNED SARDINE.

When well packed with a fair amount of oil, the Maine sardine constitutes an excellent food and gives the purchaser good value for the money expended. Table 1 shows the food value of sardines obtained for 5 and 10 cents as compared with that of various other common foodstuffs at the same price.

TABLE 1.—*Comparative food value of sardines and some other common foods.*

Food material.	Calories per pound.[1]	Protein.	Selling price per pound.[2]		Five cents bought[2]—			
					Total calories.		Calories from protein.	
			Oct. 15, 1915.[3]	Oct. 15, 1918.[4]	Oct. 15, 1915.	Oct. 15, 1918.	Oct. 15, 1915.	Oct. 15, 1918.
Sardines (in oil):								
Lean fish—		*Per cent.*						
1 quart of oil per case.	975	23.2	$0.25	$0.49	195	99	19	9
4 quarts of oil per case.	2,018	19.8	.25	.49	404	206	16	8
Fat fish—								
1 quart of oil per case..	1,270	22.4	.25	.49	254	130	18	9
4 quarts of oil per case.	2,309	19.1	.25	.49	426	236	15	8
Beef:								
Sirloin steak	985	16.5	.259	.41	190	120	13	8
Round (lean)	670	19.5	.233	.39	144	86	17	10
Cheese (whole milk)	1,950	25.9	.23	.385	424	253	23	13
Codfish:								
Fresh	165	8.4	.16	.23	52	36	11	7
Salt	315	19.0	.18	.25	88	63	21	15
Eggs	635	11.9	.266	.426	119	75	9	6
Ham (smoked)	1,670	14.5	.265	.52	315	161	11	6
Milk	325	3.3	.044	.074	369	220	15	9
Salmon (canned)	680	19.5	.198	.309	172	110	19	12

[1] Taken from U. S. Department of Agriculture, Office of Experiment Stations Bull. 28, except the figures for sardines.

[2] All prices are taken from U. S. Department of Labor, Bureau of Labor Statistics publications, except those for sardines and codfish.

[3] Calculated from 0.05 per 3¼-ounce can.

[4] Calculated from 0.10 per 3¼-ounce can.

It is evident that sardines packed from fat fish in the maximum amount of oil have a food value greater than that of any of the other common food materials of animal origin, considering only the amount which may be procured for 5 cents, the original price of a can of sardines. At 10 cents per can, sardines of this quality are outranked by whole milk cheese, at 39 cents a pound, in the number of calories that can be purchased for a given sum. Even as they are ordinarily packed, sardines compare very favorably with the amount of other animal foods which can be purchased for 5 cents. While the prices given in Table 1 no longer obtain, the comparative differences between them probably remain approximately unchanged.

The quantity of oil in the can is a very important factor in contributing to the food value of the sardine when it is eaten. A well-packed can containing an adequate amount of edible oil yields a large amount of food-fuel, and, in the form of the fish flesh, a good quantity of tissue-building food.

PURPOSE OF INVESTIGATION.

A few years before undertaking the investigation herein reported, the Bureau of Chemistry, of the United States Department of Agriculture, made several studies of sardines shipped in interstate commerce from Maine, in connection with the enforcement of the Federal Food and Drugs Act. The bureau had already acquired some experience in such work, through its study of sardines offered for importation into the United States. These investigations of Maine sardines showed that a certain portion of the pack was of unnecessarily inferior quality. Indeed, in some cases it constituted a flagrant violation of the law. It seemed probable that very often the low-quality goods were produced through faulty methods of handling and packing, due to carelessness, rather than to a deliberate effort to defraud the consumer. This condition seemed to offer an opportunity to render the packer a real service in assisting him to raise the standard of his output by employing better methods throughout the canning process, and at the same time to benefit the community as a whole by improving an important element of the country's food supply.

Accordingly, in 1913, a laboratory was established at Eastport, Me., where, during that season, as well as those of 1914 and 1916, the representatives of the Department of Agriculture, ably assisted by the packers, studied the entire process of packing sardines. The success of this undertaking is already evident in the steady betterment of factory conditions, in the adoption of methods making for efficient operation, and in the increased care shown in handling the pack from the time the fish leave the water until the can is sent out from the factory. The majority of the canners have banded themselves together in an association for the betterment of the industry, exercising its own sanitary supervision over the canning processes in the plants of its members. It is hoped that the industry will be helped by the information contained in this bulletin, which gives a report of the investigations on the canning of sardines on the coast of Maine, with suggestions for improving faulty methods, for the elimination of all unnecessary waste, and for the economical utilization of the necessary wastes.

METHODS EMPLOYED IN PACKING SARDINES.

The various steps in the production of canned sardines may be classified as follows: (*a*) Catching the fish; (*b*) transportation of the fish from the fishing grounds to the cannery; (*c*) pickling and salting;

(*d*) flaking, as the process of distributing the fish upon the flakes for drying is termed; (*e*) steaming; (*f*) drying; (*g*) packing the fish in the cans; (*h*) introduction of oil into the cans; (*i*) sealing the cans; (*j*) processing or sterilization of the sealed cans; (*k*) testing the cans after processing; (*l*) shooking for shipment. In some canneries frying in oil after the fish have been dried is substituted for steaming. A brief outline of each of these steps will be first given in order that a general idea may be had of the factory operations.

FISHING.

As a rule, the small sea herring, used in the preparation of the Maine sardines, is caught in weirs, placed in comparatively shallow water along the shore. Most of the weirs are located in Canadian waters. In 1901, Bensley(1) estimated that each season between 700 and 800 weirs operated for catching these fish under licenses issued by the Dominion Government. Prince (23), in an earlier report, stated that 95 per cent of the American sardines are caught by Canadian fishermen. A weir (Pl. I) is a large circular or heart-shaped inclosure, made by driving stakes into the bottom of the sea, and intertwining brush between the stakes. Many of the oldest forms, which are known as "brush weirs," are still employed on the coast of Maine. The first "brush weir" to be constructed in this region was in use during the season of 1914. In this type, brush is placed above the surface of the water, as well as below. It is attached to posts, and extends but a few feet above the surface of the water at high tide. In many of the more recently built weirs, the brush is replaced by seine, or twine, which is removed during the winter.

The fish are directed into the weir by a lead made of brush, driven into the sea bottom, extending from the shore to the mouth of the weir. When a supply of fish has entered the weir, a net is dropped over the mouth, and the fish are seined (Pl. II, fig. 1) with a purse seine, then bailed into dories from which they are transferred to the sardine fishing boats. Some of the weirs near Grand Manan Island are large enough to permit the entrance of the sardine boats themselves, in which case the fish are bailed or hoisted directly into the large boats (Pl. II, fig. 2).

Occasionally, when the fish remain off the shore, or for any reason do not enter the weir, the fishermen resort to seining. Fish taken in this way, however, are generally considered less desirable for packing than those from weirs, because of the large amount of feed often present in their digestive tracts. Since seined fish taken in the evening are not delivered to the cannery until the following morning, a certain amount of spoilage may occur during the night while they are held in the boat. The State of Maine has enacted laws restricting the seining of fish(17). Ordinarily the sea herring is caught while in search of food, or while actively engaged in feeding. Consequently, weir fish also contain "feed," at times in great quantities. Such fish, however, free themselves of excessive feed if left long enough in the weir.

TRANSPORTATION.

Most of the boats which carry the fish from the fishing grounds to the canneries are now well equipped and admirably suited to the purpose (Pl. III). The sailing vessels formerly used have been superseded by boats equipped not only with sails but also with gasoline engines as auxiliary power, and have a carrying capacity of from 10 to 100 hogsheads [1] of fish. Each boat is provided, below decks, with a large tank or hold, which in the newer boats is watertight, to prevent the entrance of bilge water. The fish are carried in these tanks. The fishing fleet comprises privately owned boats, as well as those belonging to the various canneries. The fish are bought at the weirs by the captains of the boats, who act as agents for the canneries employing them. In addition to the cost of the fish, the canner pays the boatman for transportation at a stipulated rate, usually (1914) from $1.50 to $2.50 per hogshead, according to the distance the fish are carried.

PICKLING AND SALTING.

In early years the fish were taken in the fresh state to the canneries (Pl. IV), where they were held in tanks of strong brine for about two hours, or until they "struck," a term applied by the experienced fishman in the pickling sheds to indicate the condition of the skin and the appearance of the fish when properly salted. At present, in order to save time during transportation, salt is sprinkled liberally throughout the mass of the fish as they are placed in the hold of the boat, the amount varying from 1 to 2½ sacks, of about 190 pounds each, to the hogshead, according to the length of time it takes to reach the cannery and the quality of the fish, as judged by the boatman. Or a strong brine, made by adding the proper proportion of sea water to the fish, and salt may be used. The addition of dry salt draws out from the fish enough water to form a pickle, which sometimes is pumped off and at other times allowed to remain. As a rule, when the sea is rough no water is added, and the pickle formed by the addition of salt is pumped off during the voyage, so that the fish may be carried in practically a solid bulk, thus preventing damage to them from the rolling of the vessel.

At the cannery the fish are hoisted from the boat (Pl. III, fig. 2) into long chutes down which they are conveyed by a stream of running water into tanks in the pickling room. If the fish have been long enough in salt during the trip to the cannery, they are simply

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[1] In practice, on the "Eastern Coast," as the shore from Jonesport eastward is termed, a hogshead is rated as holding 10 tubs of fish, the weight of which is 1,000 pounds. The average weight of a number of tubs of fish, when taken at the weirs, has been found to be 129 pounds, thus making the weight of a hogshead 1,290 pounds. On the coast west of Jonesport, known locally as the "Western Coast," the fish are sold by the bushel, 15 bushels being considered as the equivalent of a hogshead.

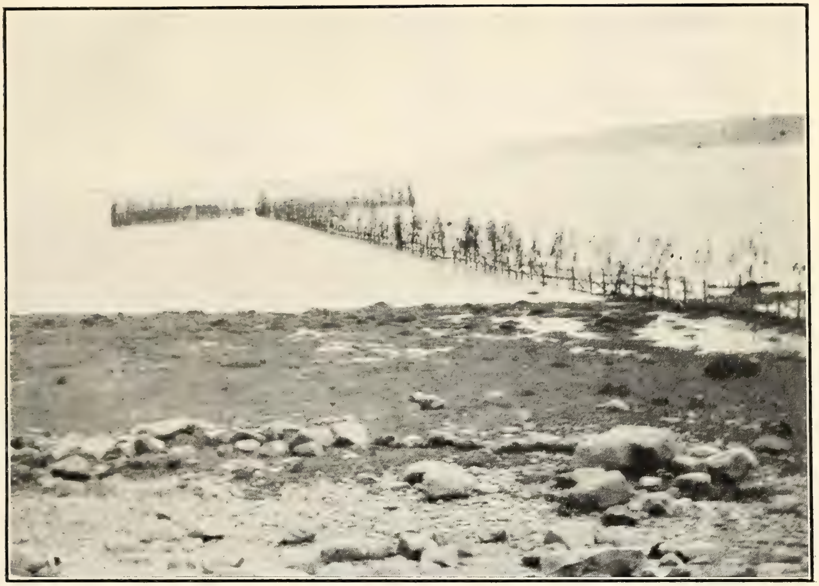

FIG. I.—BRUSH WEIR ON THE COAST OF MAINE.

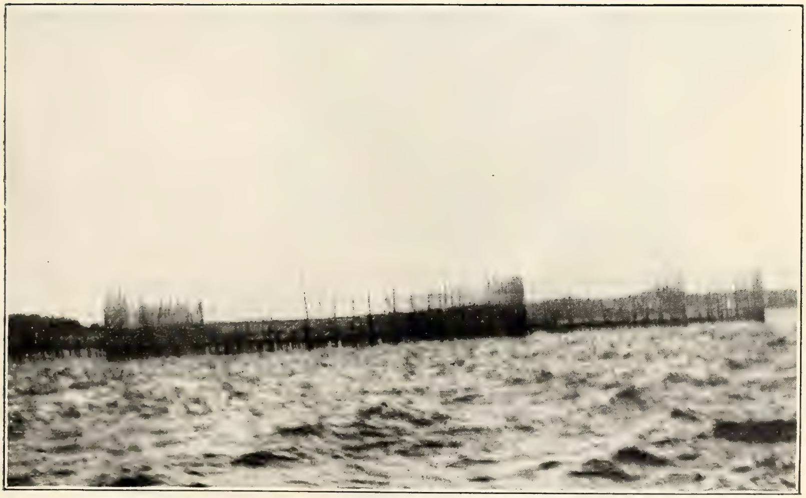

FIG. 2.—A WEIR (LEFT) PROVIDED WITH A POUND (RIGHT).

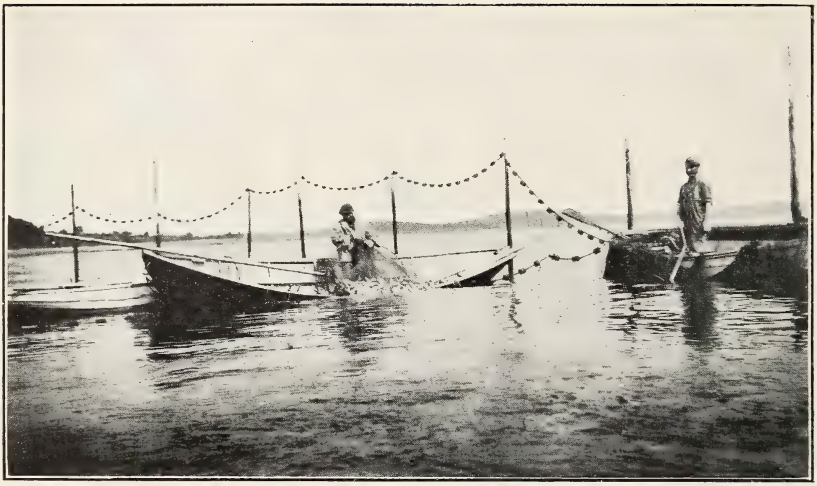

FIG. 1.—SEINING THE WEIR.

Hauling the fish, by means of small dip nets, into dories, from which they are later transferred to the larger boats.

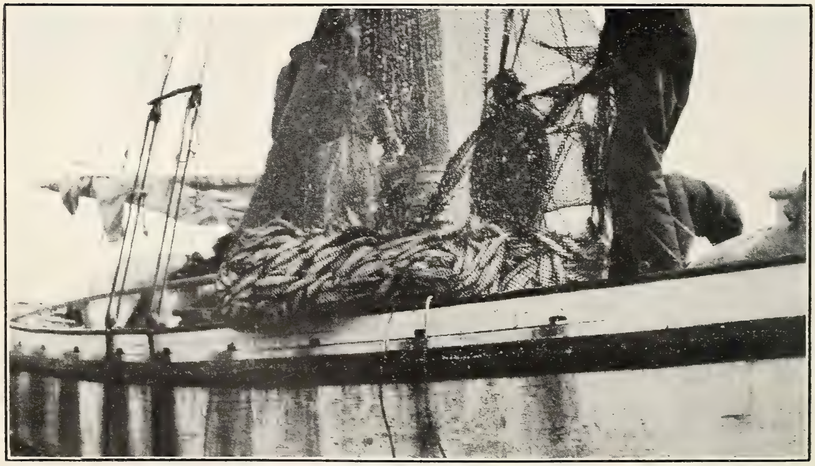

FIG. 2.—SEINING THE WEIR.

Hauling the fish directly into the sardine boats by means of a large seine.

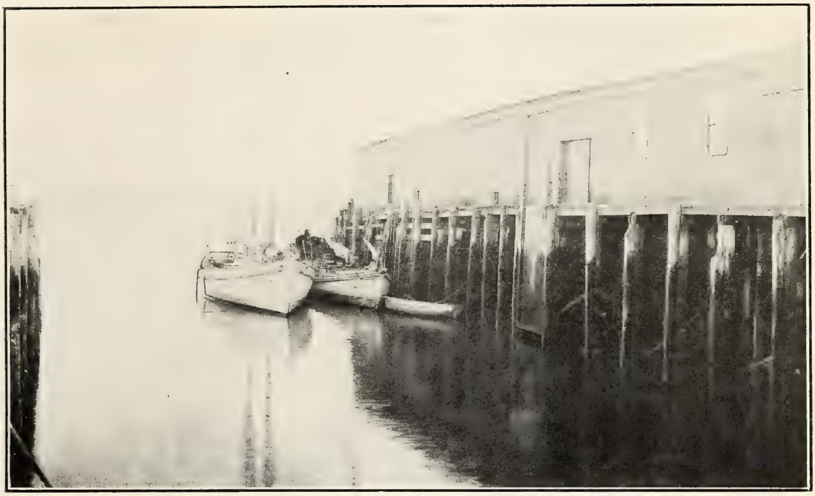

FIG. 1.—TYPICAL SARDINE FISHING BOATS.

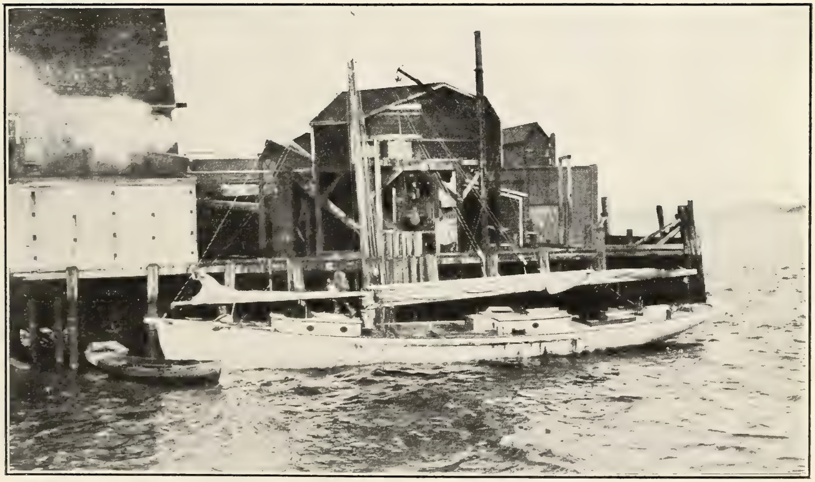

FIG. 2.—UNLOADING FISH AT CANNERY.

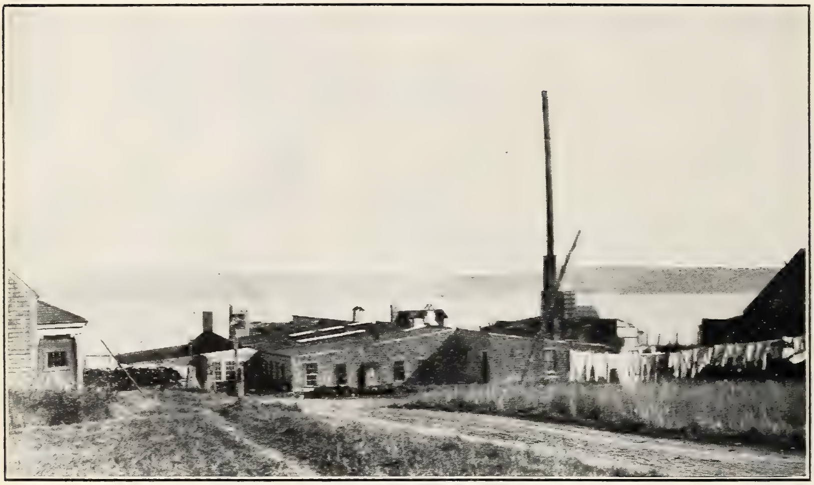

FIG. 1.—OLD TYPE OF MAINE SARDINE CANNERY.

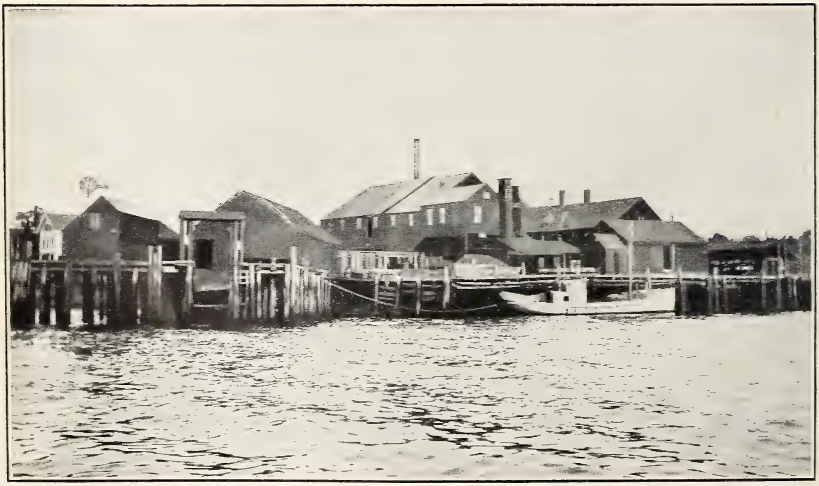

FIG. 2.—MODERN MAINE SARDINE CANNERY.

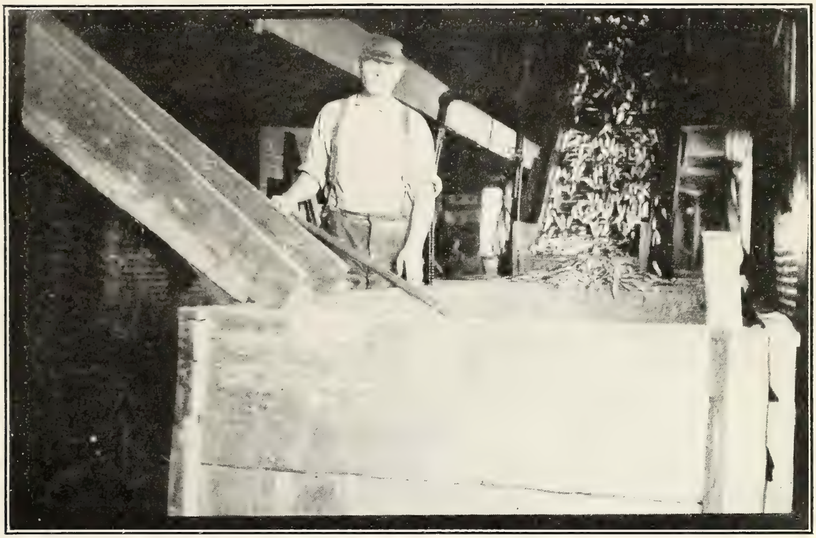

FIG. 1.—SCOOPING FISH FROM PICKLING TANK ONTO THE TAIL OF THE FLAKING MACHINE.

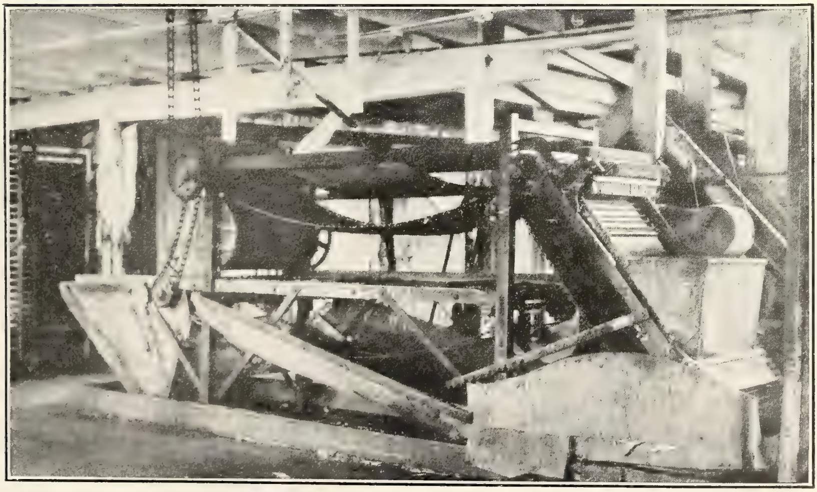

FIG. 2.—FLAKING MACHINE.

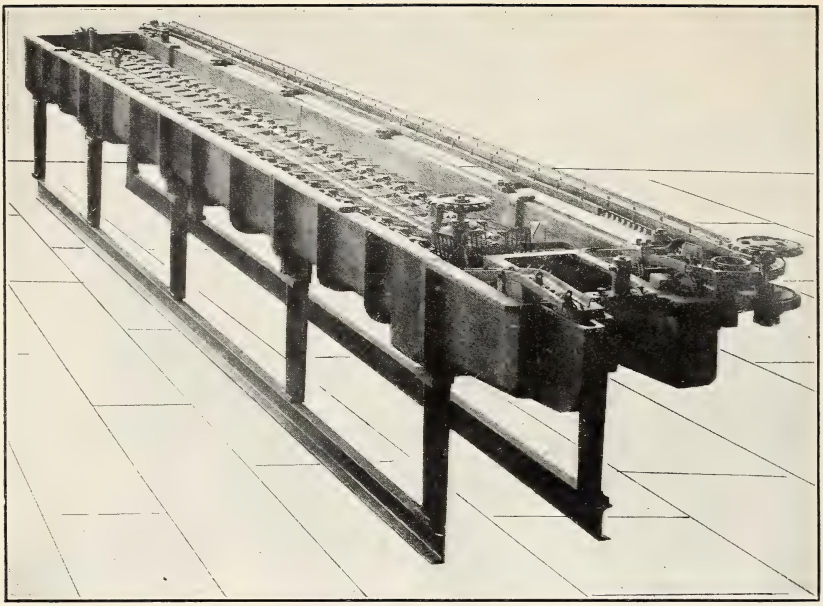

FIG. 1.—MACHINE FOR FRYING FISH IN OIL.

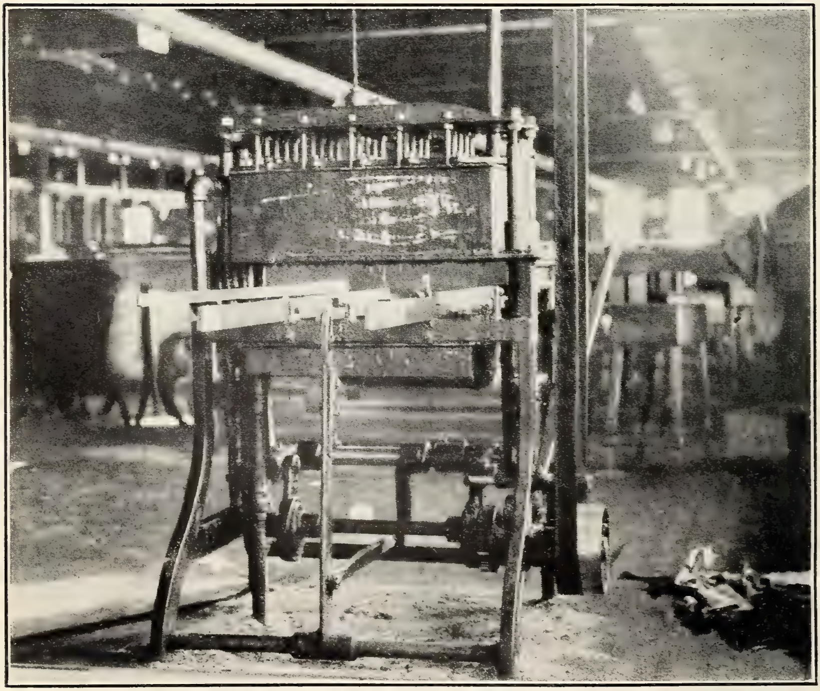

FIG. 2.—MACHINE WHICH AUTOMATICALLY DELIVERS A DEFINITE QUANTITY OF OIL TO PACKED CANS OF FISH.

passed through tanks containing very weak pickle. If they have not been sufficiently pickled during transportation, they are held in tanks filled with strong brine for from one to two hours.

FLAKING.

In a few canneries the fish are beheaded as soon as they are taken from the boats, but, as a rule, the whole salted fish are bailed from the pickling tank into the receiving trough of the flaking machine. The traveling apron of the machine (Pl. V, fig. 1) extends from the floor above into the pickling room below. Carried along by the traveling apron to this machine, the sardines are distributed, more or less evenly, depending upon the manner in which the machine is operated, on the flakes, square or rectangular wire frames, about 3 by 1½ feet, securely bound around the edge with a 1-inch galvanized metal band (Pl. V, fig. 2). Several of the canneries putting out a superior quality of sardines distribute, or flake, the fish by hand, thus securing a very even distribution on the flakes, a most important factor in the production of quality in the pack. The flakes carry the fish through the rest of the canning process until they are ready to be placed in the cans.

STEAMING.

From the flaking machine, the flakes are passed, on racks mounted on wheels, or, in a few cases, suspended from a track on the ceiling, to the steam chest. Here the fish are subjected to treatment with live steam for from 10 to 15 minutes.

DRYING.

The racks containing the steamed flaked fish are next taken to the drying chamber, where they are brought to the proper degree of dryness by one of several methods. Three types of driers are in use at the present time: The tunnel or "air" drier; the kiln or "oven" drier; and a combination of the kiln drier with a "Ferris wheel." In the tunnel drier, which method has practically superseded the once popular Ferris wheel device(29), as well as the old-fashioned kiln drier, the air, heated by being passed over steam coils, or by waste flue gases, is blown or drawn over the racks of fish. Where the kiln drier or Ferris wheel drier is still in use a glowing bed of anthracite coal supplies the heat.

FRYING IN OIL.

In canneries where the sardines are fried in oil, the fish, after having been flaked, either by hand or by a well-operated machine, are dried in the usual manner, without, however, having been put through the steam chest, transferred to frying baskets which are immersed in hot oil, cooked, cooled, and packed in cans (Pl. VI, fig. 1). From this point the procedure is the same as for the steamed fish.

FILLING THE CANS.

From the driers, the racks are taken to the packing room, where women first remove the heads of the fish by cutting with scissors ("shearing"), or, if the sardines are small, by snipping them off with the fingers ("snipping"). The fish are then packed in the cans. In most canneries the filled cans are placed in rectangular pans, with a capacity of 25 cans each, the pans being then stacked in tiers and carried on trucks to the sealing machine. In others the cans are passed directly to a traveling belt which carries them to the oiling and sealing machines.

ADDING THE OIL.

In plants where the oiling device is not attached to the sealing machine the cans are taken from the packing room to an automatic machine (Pl. VI, fig. 2), which can be set to deliver a definite amount of oil to each can. Twenty-five cans may be filled with oil each time a pan containing this number passes through it. Similar oiling machines are sometimes operated by a hand lever.

In many canneries, however, the oiling device is attached to the sealing machine, making it possible to accomplish these two steps in one operation.

SEALING THE CANS.

At the sealing machine the covers are placed on the cans filled with sardines and oil and passed through the rolls. Three different types of machines are in use for closing sardine cans. The machines in most general use are equipped with rolls which travel around the projecting edges of the can and the lid as it fits over the can, crimping the edges of the can and the lid together and at the same time compressing them (Pl. VII, fig. 1). Another type of machine seals the lid on by direct compression. The can is held firmly between jaws which close together, crimping the lid upon the cans (Pl. VII, fig. 2). The third method hermetically seals the cans by the use of solder, which is placed upon the edge of the can. The lid and can are then passed, by means of a mechanical device, under heated rolls.

PROCESSING OR STERILIZATION.

The sealed cans are processed in tanks of boiling water for one and three-fourths to two and one-fourth, sometimes two and one-half, hours, according to the individual packer's idea of the time necessary for sterilization. One or two canneries employ retorts for sterilization. These are cast-iron cylindrical or rectangular steam-heated kettles with tightly fitting covers or doors, the contents of which can be heated under pressure.

STORING THE CANS.

After processing the cans are removed from the tanks, dried, and partially cleaned (Pl. VIII, fig. 1) by mixing them with sawdust and shoveling sawdust over them. They are then sent to the storage room below and allowed to cool (Pl. VIII, fig. 2), after which each can is tested and then packed in a shipping case, or, as it is termed by the trade, "shook."

THE CANS.

As already stated, the cans used for packing sardines in oil are designated, according to their size, as quarter oil, high-quarter oil, and half oil, while those used for packing sardines in mustard sauce are called quarter mustard and three-quarter mustard. The quarter oil and the quarter mustard cans are the same size. The greater part of the sardine pack is put up in oil, in the quarter size cans, and about 25 per cent of the normal output in mustard sauce, mostly in the three-quarter size cans. Lacquered cans, made from tin coated with a preparation which prevents the action of the acid in the sauce upon the metal, are employed only for mustard sardines. A case of quarter oil or mustard sardines contains 100 cans, while a case of three-quarter size mustards contains 48 cans.

The cans used for both oils and mustards are divided into two classes, the key-opening and the keyless. Projecting from the corner of the key-opening or three-piece can, the bottom of which is soldered on, is a small lip to which the key for opening the can is attached. One objection to this type of can is that, in order to open it with the "brights" up, the fish must be packed with the belly portions against the bottom of the can. It is practically impossible to inspect properly the quality of the fish placed in such cans or the manner in which they have been packed. These cans also are more subject to small leaks than are some of the other types. The key-opening two-piece can, provided with a scored top, lacks some of the objectionable features of the three-piece can, but is less successfully opened. The keyless cans, also called drawn cans, or two-piece cans, are stamped directly from sheets of tin by means of a power press and die. Key openers for these cans are made by scoring the covers around the edges and providing a projecting lip at one corner or at the end for the key.

TABLE 2.—*Size of sardine cans.*[1]

Type of can.	Length.		Width.		Height.		Lid set in.	
	Inches.	Centimeters.	Inches.	Centimeters.	Inches.	Centimeters.	Inches.	Centimeters.
Three-quarter mustard (keyless)	$4\frac{21}{32}$	11.9	$3\frac{14}{32}$	8.8	$1\frac{15}{32}$	3.8	$\frac{5}{32}$	0.35
Half oil (key)	$4\frac{17}{32}$	11.6	$3\frac{11}{32}$	8.5	$1\frac{2}{32}$	2.7	$\frac{4}{32}$	.3
One-quarter oil and mustard, drawn can (keyless)	$4\frac{6}{32}$	10.7	$2\frac{30}{32}$	7.5	$\frac{25}{32}$	2.0	$\frac{4}{32}$	.3
Do.	$4\frac{4}{32}$	10.55	$2\frac{30}{32}$	7.5	$\frac{25}{32}$	2.0	$\frac{5}{32}$	.35
One-quarter oil and mustard, 3-piece can (key)	$4\frac{6}{32}$	10.7	$2\frac{31}{32}$	7.6	$\frac{24}{32}$	1.9	$\frac{4}{32}$	.3
Do.	$4\frac{5}{32}$	10.6	$2\frac{31}{32}$	7.6	$\frac{23}{32}$	1.8	$\frac{5}{32}$	.35
High-quarter	$4\frac{5}{32}$	10.6	$2\frac{31}{32}$	7.6	$1\frac{4}{32}$	2.9	$\frac{5}{32}$	.35

---

[1] Since these measurements were taken, the height of the one-quarter cans has been reduced $\frac{1}{32}$ inch. In view of other possible changes, these dimensions may not be exactly correct to the fractions of inches or centimeters.

Table 2 gives the inside measurements, expressed in inches and centimeters, of representative types of the cans in use. This will serve as a reference and give a general idea of the size of cans in which sardines are commonly packed.

The size of the sardine cans varies from the keyless one-quarter oil and mustard drawn can, which is $4\frac{1}{8}$ inches long, $2\frac{15}{16}$ inches wide, and $\frac{25}{32}$ inch high, with the cover set in $\frac{5}{32}$ inch, to the keyless three-quarter mustard size, which is $4\frac{21}{32}$ inches long, $3\frac{7}{16}$ inches wide, and $1\frac{15}{32}$ inches high, with the cover set in $\frac{5}{32}$ inch. The capacity of the low-quarter cans in use during the seasons of 1913 and 1914 varied from 154 to 157 cc in the case of the keyless type, and from 150 to 156 cc for the key cans. With the covers on, the capacity was from 120 to 125 cc and from 112 to 114 cc, respectively, for the two types.

At the present time, the low-quarter and three-quarter cans (Pl. IX) are more commonly used than the high-quarter and half sizes. The number of the half-size and the high-quarter cans used, however, increased greatly in 1916, and it is expected that as the quality of the pack improves, sardines in larger cans will be more in demand. The quarter-size cans, designated as high-quarter and low-quarter (Pl. IX, figs. 1 and 2), have the same length and width, while the height of the low-quarter size is $\frac{7}{8}$ inch and that of the high-quarter cans $1\frac{1}{8}$ inches. Both types come in the form of three-piece cans, with key openers, and also as the keyless, drawn cans. The same size cover serves for both types. The three-quarter mustard cans are $\frac{13}{32}$ inch higher than the half oils (Pl. IX, figs. 3 and 4); otherwise the two varieties are of the same size. Both come with the bottom soldered on, to permit the use of the key-opening device, but the bottom of the keyless three-quarter can is rolled on. The same covers fit both types. The half oil can is the only style in that size now made, and it is not used as extensively as its merits would seem to warrant.

The empty cans are delivered from the can factory to the cannery in the shooks or shipping cases, and are generally stored in the canneries until they are needed. The covers are handled separately, in large bulk, in special boxes, or crates, for containers.

EXPERIMENTAL WORK.

METHODS OF ANALYSIS.

The methods of analysis used, which were adopted after preliminary experiments had been made with them, are as follows:

SAMPLING.

Take a quantity of fish large enough to represent fairly the entire lot. Wipe with a dry towel or spread out on paper for an instant, to remove the water adhering to the surface of the fish. Behead and eviscerate, as the case requires, and thoroughly grind and mix by passing a number of times through a meat grinder, previously dried. Sample and transfer to a pint size, screw-cap Mason jar, provided with the usual rubber gasket, portions of this lot sufficient for analysis.

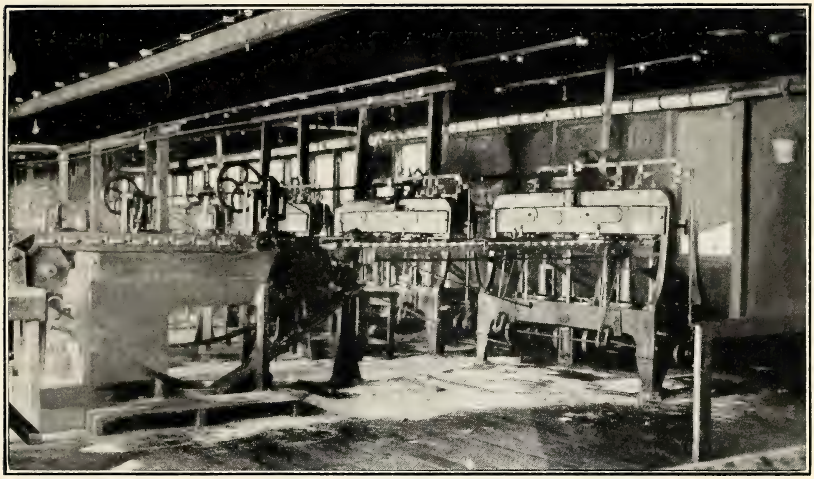

FIG. 1.—ROLL TYPE SEALING MACHINES.

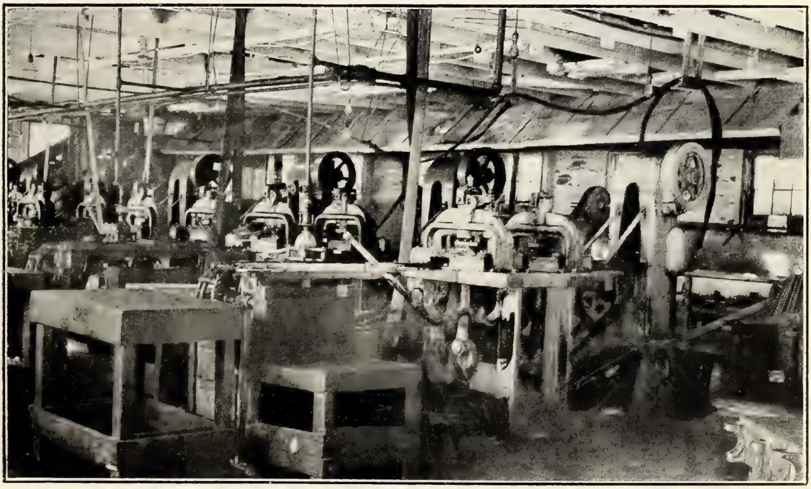

FIG. 2.—COMPRESSION TYPE SEALING MACHINES.

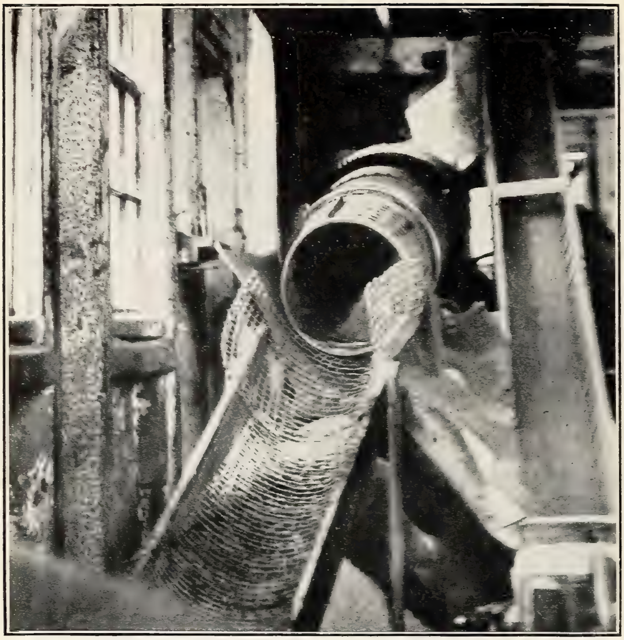

FIG. 1.—DEVICE FOR CLEANING CANS.

Sawdust is passed down the rotating tube with the cans.

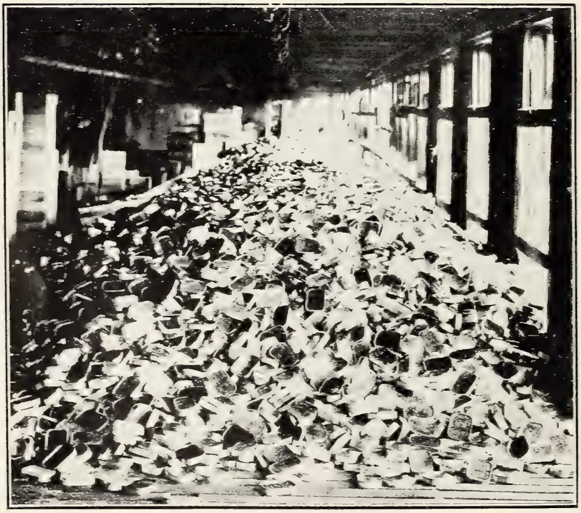

FIG. 2.—CANS OF SARDINES AFTER THEY HAVE BEEN PROCESSED.

It may take from 8 to 10 hours for the interior of such a pile, which is 100 feet long, 8 feet wide, and from 4 to 5 feet deep, to lose its heat.

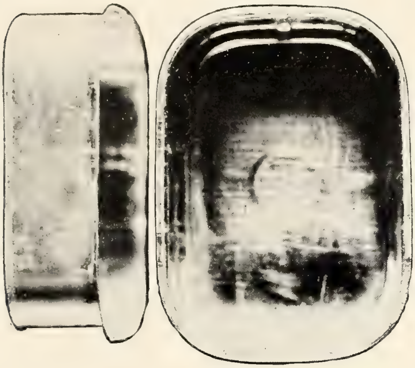

FIG. 1.—HIGH-QUARTER OIL SARDINE CAN.

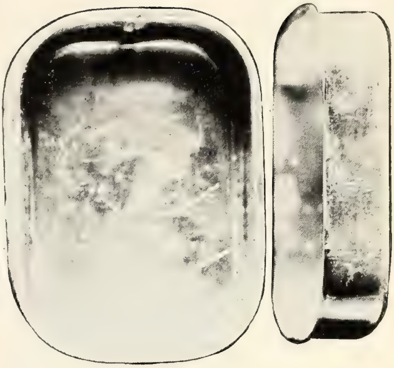

FIG. 2.—ORDINARY LOW-QUARTER OIL SARDINE CAN.

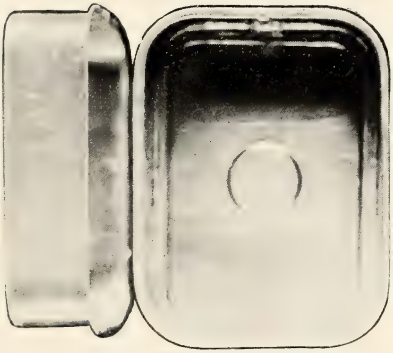

FIG. 3.—ONE-HALF OIL SARDINE CAN.

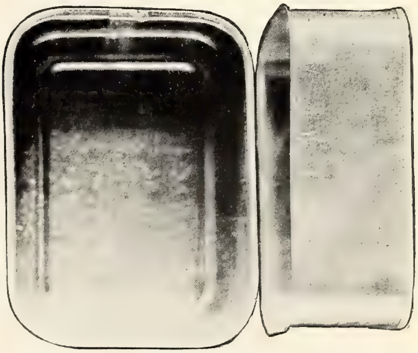

FIG. 4.—THREE-QUARTER MUSTARD SARDINE CAN.

In the same way, by grinding and mixing through the meat chopper, prepare the contents of the cans. Wipe the last traces of oil from the interior of the can with the ground fish.

MOISTURE.

Spread thinly 2 or 3 grams of sample in 2½-inch lead-foil caps, and dry in vacuo (25 to 28 inches) for 5 hours at 55° C.

FAT.

Extract the dried residues from the moisture determinations for from 12 to 15 hours in a Knorr fat extraction apparatus with 50 cc of absolute ether, prepared over sodium. Evaporate the ether at as low a temperature as possible, and dry the ether extract 1 hour at 55° C. in vacuo.

ACIDITY OF FAT(9).

Dissolve the dried ether extract residues in 50 cc of benzol. Add 2 drops of phenolphthalein and determine the acidity by titrating with N/20 sodium ethylate. Calculate the acidity as cc of N/20 sodium ethylate per 1 gram of fat.

TOTAL NITROGEN.

Determine by the Gunning modification of the Kjeldahl method (A. O. A. C. Methods, 1916, p. 7).

AMMONIA NITROGEN.

Nessler(8).[1]—Weigh 3-gram samples and transfer to large test tubes, or small Kjeldahl flasks, with 20 to 25 cc of water. Add 3 cc of 10 per cent solution of potassium carbonate, 3 cc of 15 per cent solution of potassium oxalate, and a little heavy cylinder oil. Pass a strong current of ammonia-free air through this mixture for four hours. Collect the ammonia in 5 cc of N/20 sulphuric acid contained in a 100-cc volumetric flask. After aerating, dilute the contents of the flask to the 100-cc mark. Transfer a 25-cc aliquot portion to a 100-cc volumetric flask and dilute nearly to the mark. After adding 2 cc of Nessler solution and making to volume, compare the density of the color of the solution in a Duboscq colorimeter with that of a known standard.

Titration.—Weigh 3-gram samples and transfer to large test tubes, or small Kjeldahl flasks, with 20 to 25 cc of water. Add 3 cc of 10 per cent solution of potassium carbonate, 3 cc of 15 per cent solution of potassium oxalate, and a little cylinder oil. Force a strong current of ammonia-free air through this mixture for four hours. Collect the ammonia in 5 cc N/20 sulphuric acid, in a 100-cc volumetric flask. After aeration, titrate the excess acid in the flasks with N/50 alkali, using methyl red as the indicator.

TOTAL VOLATILE NITROGEN FOR THE SEPARATION OF AMMONIA AND AMINES.

Weigh thirty 3-gram samples into tubes of the Folin apparatus, or small Kjeldahl flasks, arranged for the aeration method for the determination of ammonia. To each add about 25 cc ammonia-free water, a pinch of sodium fluorid, 3 cc of 15 per cent potassium oxalate, and 3 cc of 10 per cent potassium carbonate. Aerate four hours. Collect the alkaline volatile nitrogen compounds in 5 cc of N/20 sulphuric acid. After the necessary time has elapsed, remove the flasks, and titrate back with N/50 potassium hydroxid. Use methyl red for the indicator. The acid used is equivalent to the total volatile nitrogen, that is, the sum of the ammonia and amines present.

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[1] Although a number of determinations of ammonia by the Nessler method were made, they are reported in only a few of the tables. The term "ammonia," as used in the tables and text, represents the total volatile alkaline material (ammonia and amines) as determined by the titration method. In the decomposition studies, and the work on the formation of ammonia and amines here reported, the total volatile alkaline bases are separated into the amines and ammonia. In the work on the decomposition of the copepods (feed), and on the influence of the temperature of storage on the formation of ammonia and amines, the amines were further separated into their three classes by a method recently devised.

SEPARATION OF AMMONIA FROM AMINES (6).

Unite the distillates obtained by the preceding method in a large dish, make distinctly acid, and evaporate until the volume is about 400 cc. Wash into a 500-cc graduated flask, and cool. If the total volatile nitrogen exceeds a strength equivalent to 30 cc N/10 in amount, make up to 500 cc, and transfer a portion equivalent to 20 to 30 cc of N/10 to another 500-cc flask. If the amount of total volatile nitrogen is less than the equivalent of 20 cc N/10, add enough of a standard solution of ammonia to raise the content to that point. Add to the liquid in the 500-cc graduated flask 10 cc of a solution made by mixing equal parts of 20 per cent sodium hydroxid and 30 per cent sodium carbonate. Fill to the mark with water. Now add 0.1 gram of yellow mercuric oxid for each cc of N/10 acid to which the total volatile nitrogen present in the solution is equivalent. Stopper tightly, cover with a black cloth to exclude light, and shake one hour. Allow to stand 12 hours, or overnight, to permit the oxid of mercury to settle. Separate from the mercuric oxid by forcing the liquid through a tube containing a little absorbent cotton, using a moderate blast. Discard the first 20–30 cc. Distill 200 cc of the filtrate in duplicate into standardized acid. The amount of acid required is equivalent to the nitrogen present as amines. The total volatile nitrogen minus the amine nitrogen equals ammonia nitrogen. Express the quantities as milligrams of nitrogen per 100 grams of sample.

AMINO ACID NITROGEN.

The few determinations of amino acid reported were made in Klein's (14) modification of Van Slyke's apparatus, before the latest Van Slyke method was published.

VOLATILE SULPHUR.

Weigh 100-gram samples into 800-cc Erlenmeyer flasks, to which have been added 400 cc of water and 10 cc of a 20 per cent solution of phosphoric acid. Distill 150 cc into an excess of N/20 potassium hydroxid by steam distillation in 45 minutes. Neutralize the excess of alkali by titration with N/20 hydrochloric acid. To the distillate add 25 cc of approximately N/100 iodin solution, and, after allowing it to stand from 5 to 10 minutes, titrate the unreduced iodin with N/100 thiosulphate solution. Calculate the volatile sulphur as cubic centimeters of N/100 iodin per 100 grams of fish.

CHLORIN.

Sodium chlorid (*salt*).—Determine by the Volhard method(31), after the samples have been ashed at a low temperature with an excess of bicarbonate of soda, free from chlorin.

TIN.

Add 50 cc of concentrated sulphuric acid to the material in a Kjeldahl flask, and add concentrated nitric acid, boiling until all organic matter is destroyed. Rinse out the flask into a 600-cc beaker with boiling water, diluting to 400 cc. Neutralize with ammonium hydroxid, and add 5 cc hydrochloric acid. Heat on hot plate to 95° C., cover with a watch glass, and pass in a slow stream of hydrogen sulphid for one hour. Digest on a hot plate for two hours. Filter, using an 11-cm S. & S. filter. Wash with three portions of a wash solution (composed of 100 cc saturated ammonium acetate, 50 cc glacial acetic acid, 850 cc water) alternated with three portions of hot water. Place filter and precipitate in a 50-cc beaker and digest with three successive portions of ammonium polysulphid, bringing to a boil each time and filtering through a 9 cm filter. Wash with hot water. Acidify with acetic acid, digest on a hot plate for one hour, and filter through a double 11-cm filter. Wash with two portions of wash solution alternated with two portions of hot water. Place filter and precipitate in weighed porcelain crucible and dry at 110° C. Ignite very gently at first, later with the full burner. Finally heat strongly with a large Meeker burner or blast lamp. Weigh as oxid of tin, and calculate percentage of milligrams of tin.

COMPOSITION OF THE SEA HERRING.

The average composition of the fresh herring, as determined from results obtained throughout the season, is given in Table 3.

TABLE 3.—*Average composition of sea herring.*

Herring.	Water.	Protein.	Fat (ether extract).[1]	Ash (mineral matter).
	Per cent.	*Per cent.*	*Per cent.*	*Per cent.*
Lean	72.5	19.5	6.5	1.5
Fat	68.5	14.3	16.0	1.2

[1] The fat content of these fish may vary from 5 to 18 per cent during the packing season.

VARIATION IN FAT AND WATER CONTENT OF THE FISH.

Several investigators have noted the fact that the fat content of fish varies with the season, being noticeably low in the spring. Few analyses showing the difference in composition and seasonal variation in the fat content of fish have, however, been reported. According to Dr. John Hjort, director of fisheries of Norway (12), the maximum fat content, 15.52 per cent, in the Norwegian sardine (the brisling) is found in September, and the minimum amount, 4.65 per cent, in April. The amount of fat stored up in the muscular tissue and viscera of the herring during the summer is consumed during the winter. Conversely, the water content is lower during the summer than in the winter months. This fish is inferior in quality through the winter, or period of low fat content. In discussing the quality of fish used for packing sardines, Dr. Hjort stated that "The quality of all three species, herring, brisling, and pilchard, is a feature which changes with age and season."

H. Lichtenfelt (15) states that the muscular tissue of fish changes in composition at definite periods of the year, the fat content depending on the age of the fish, the food eaten, and the spawning season. During the hunger period (scarcity of food) the percentage of water increases, while that of dry matter and of protein decrease.

Milroy (18) found great differences in the composition of the muscles of fish of larger size than are commonly used for sardines, taken from the same waters in different months. The percentage of fat in fish, the ovaries of which were immature, was in the summer about the same as the average for herring. During August, September, and October the percentage of fat continued to increase. It decreased slightly in November, more in December, and most markedly during spawning, continuing at a low level until the fish began to feed again. This investigator points out the probability that the decrease in fat in the muscle tissues of the fish is accompanied by an increase in the water content.

The herring studied by Heinecke (18) contained the largest amount of fat during September and October.

According to Johnstone (13), the full and unripe herrings caught during the summer (June to August) are much richer in fat or oil than the same kind of herring caught during the fall and winter (October to December). His results show also that the percentage variation in the water and fat content of the fish is closely complementary.

The monthly variations in the water and fat contents of the Maine herring of various sardine sizes as they were brought to the canneries are shown in Table 4. The analyses were made not on the fresh fish, but on fish which had been held in salt or pickle for varying periods. The results are therefore influenced by the salt taken up by the fish and the amount of water and extractive material lost, and can not be considered as representative of fresh fish.

TABLE 4.—*Water and fat content of sea herring by months (1913).*

Description of fish and month caught.	Number of samples.	Water.			Fat.		
		Maximum.	Minimum.	Average.	Maximum.	Minimum.	Average.
July:							
Oil size—		*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*
Not eviscerated	6	70.91	53.23	65.28	5.55	3.93	4.80
Eviscerated	2	69.68	61.54	65.61	6.06	4.36	5.21
Mustard size—							
Not eviscerated	10	66.90	48.72	61.99	18.61	7.21	12.94
Eviscerated	4	64.10	52.84	60.06	14.24	9.26	13.01
August:							
Oil size—							
Not eviscerated	10	71.28	60.62	65.32	11.25	6.03	9.48
Eviscerated	1	64.60	64.60	64.60	7.30	7.30	7.30
Mustard size—							
Not eviscerated	4	65.32	58.32	61.62	15.63	11.87	13.44
Eviscerated	1	62.46	62.46	62.46	12.38	12.38	12.38
September:							
Oil size—							
Not eviscerated	4	70.38	60.08	67.74	8.49	5.31	6.31
Mustard size—							
Not eviscerated	4	64.85	59.96	62.43	15.07	8.54	11.32
October:							
Oil size—							
Not eviscerated	8	72.16	59.13	65.10	14.25	5.09	8.75
Eviscerated	3	71.51	64.55	69.18	9.68	7.84	9.00
Mustard size—							
Not eviscerated	3	68.13	55.54	59.81	16.00	10.56	13.16

The average fat content of the oil-size fish was greatest in August, in the case of the uneviscerated fish, and in October in the case of the eviscerated fish. In July the fat content was comparatively low for each. The mustard size, or larger, fish did not show an appreciable increase from one month to the next, containing approximately 13 per cent of fat from July until October.

The low fat content for the oil-size fish found in September is accounted for by the fact that a number of analyses made on fish obtained from Castine, Me., are included. It is said that large numbers of these fish run into this bay, where they remain until long after the food supply is exhausted, thus becoming very thin.

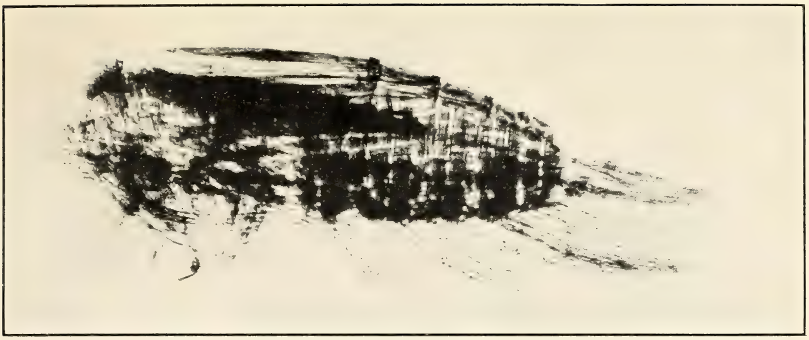

FIG. 1.—COPEPOD—CALANUS FINMARCHICUS (MAGNIFIED 26 TIMES).

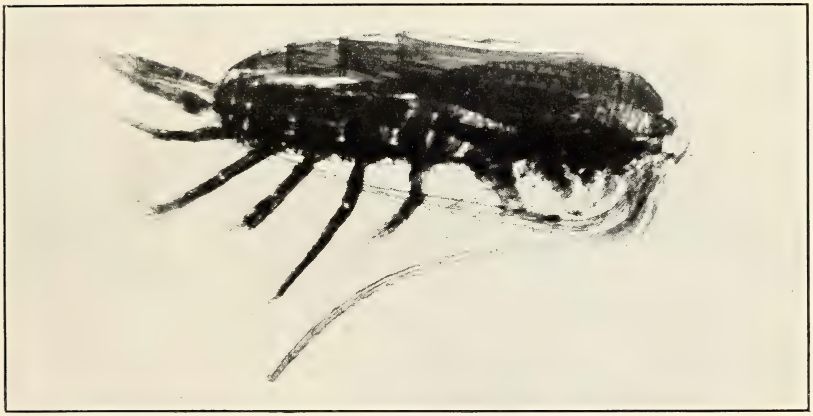

FIG. 2.—COPEPOD—TEMORA LONGICORNIS (MAGNIFIED 26 TIMES).

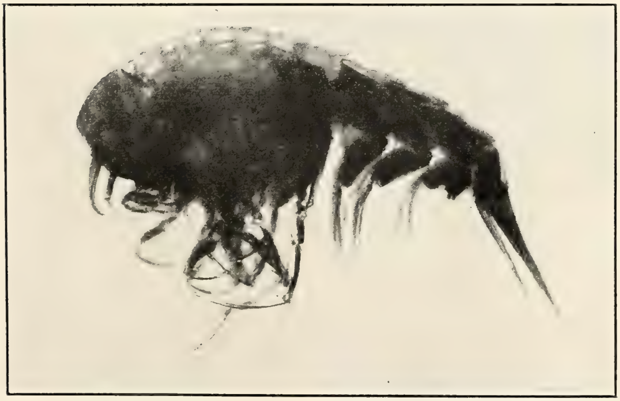

FIG. 3.—AMPHIPOD—ENTHEMISTO COMPRESSA (MAGNIFIED 3 TIMES).

THE MORE COMMON FORMS OF FEED OF THE SEA HERRING.

(Photomicrographs by E. A. Read, Microchemical Laboratory, Bureau of Chemistry.)

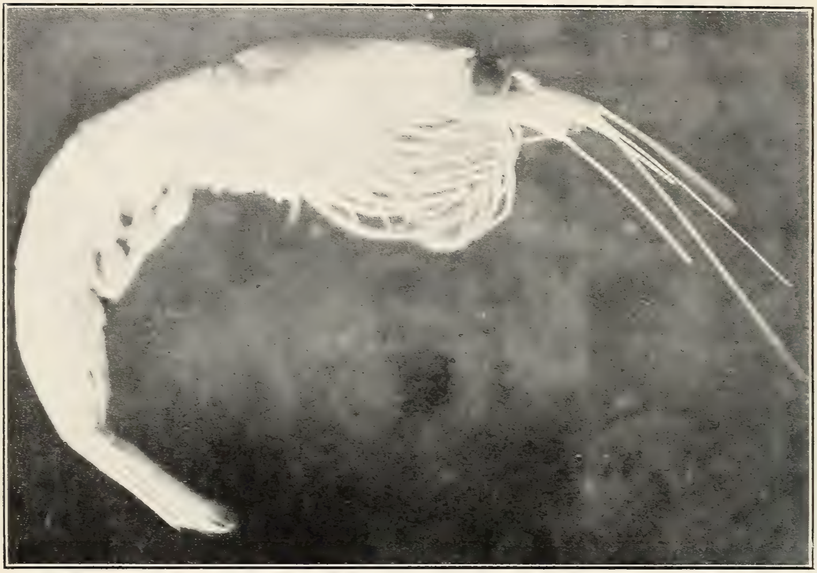

FIG. 1.—SCHIZOPOD (SHRIMP). EUPHASISID—MEGANYCTIPHANES NORWEGICA (MAGNIFIED 3 TIMES).

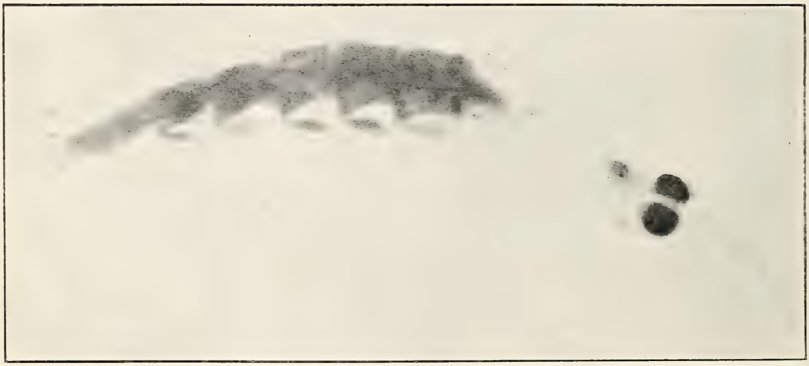

FIG. 2.—EUPHASISID—THYSANOESSA INERMIS (MAGNIFIED 6 TIMES).

THE MORE COMMON FORMS OF FEED OF THE SEA HERRING.

(Photomicrographs by E. A. Read, Microchemical Laboratory, Bureau of Chemistry.)

It is shown by these analyses that the smaller fish, of the real sardine size, contain much less fat in the early part of the packing season than later in the year.

FOOD OF THE SEA HERRING.

The sea herring, from which the Maine sardines are made, feeds upon several varieties of marine life. According to European investigators, the feed(19) consists of copepods, schizopods (shrimp-like forms), amphipods (sand fleas and their allies), the embryos of gasteropods and lamellibranchs, and young fish often of its own kind. In the examination of about 1,500 specimens at Eastport and vicinity Moore found but two kinds of food. Copepods ("red feed") appeared to constitute the sole food of the small herrings, the so-called brit, and a marked portion of that of the larger individuals from 5½ inches upward. The principal foods of the latter, however, were schizopods, crustaceans of the genus Thycanopoda, known to the fisherman as "shrimp."

Scott(26) states that of 22 species of microscopic crustaceans found in the stomachs of herrings examined by him the greater part were *Calanus finmarchicus*, *Temora longicornis*, and *Pseudocalanus elongatus*.

In an investigation on the packing of American sardines conducted by the Maine Agricultural Experiment Station, in 1911, at Eastport and Lubec(11), "red feed" was identified as the copepods *Temora longicornis*, and *Calanus finmarchicus*.

Calanus finmarchicus and *Temora longicornis* were the most numerous of the crustaceans collected in the region extending from Dochet Island to Grand Manan for the Marine Biological Station at St. Andrews, N. B.(16).

In exploring the coast water between Nova Scotia and Chesapeake Bay, July and August, 1913, Dr. Henry B. Bigelow(2) found that of the copepods the most abundant species was *Calanus finmarchicus*, the *Pseudocalanus elongatus* ranking next, while in a few regions the *Temora longicornis* was the most abundant. He considers, however, that the *Calanus finmarchicus* is the most abundant form found in the waters of the Gulf of Maine.

Apparently, therefore, the feed of the sea herring of the Passamaquoddy Bay region may be divided into two general classes:

1. The copepods[1] (Pl. X), of which *Calanus finmarchicus*, *Pseudocalanus elongatus*, and *Temora longicornis* are the species most often found, undoubtedly constitute the chief form of the "red feed." The herring consumes the copepods which, in turn, feed upon microscopic plants, such as peridinia, and diatoms. R. Ramsey Wright(40)

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[1] Identification of specimens made by the Division of Marine Invertebrates of the U. S. National Museum.

classes copepods, which are approximately one-eighth inch long, as macroscopic forms of sea life.

2. Schizopods,[1] or "shrimp" (Pl. XI), are the larger macroscopical forms on which the fish feed.

FEEDY FISH.

Fish which have been feeding extensively on either of the two kinds of food known to the fisherman as "red feed" and "shrimp" may be designated as "feedy fish." While there is little difference in the action of the two kinds of feed in rendering the fish unsuitable for packing, fish that have been feeding upon "red feed" become broken and deteriorate a little more rapidly than fish that have been feeding on shrimp. Bacteriological examination of the feed showed that the bacterium commonly associated with copepods grows faster and produces a slightly greater amount of gas than the organism found on the shrimp.

"Feedy" fish, in so far as its influence on the quality of the sardines is concerned, is perhaps the most troublesome factor in the sardine industry. Fish more or less gorged with food deteriorate very rapidly when taken from the water, while those having their digestive tracts free from food remain in good condition for a comparatively long time thereafter. As decomposition progresses the thin belly portion of the fish gradully sloughs away, producing the characteristic ragged appearance termed "belly blown." The rate of deterioration depends upon the quantity of and the stage of digestion of the food material contained in the digestive tract, and the bacteria accompanying it. Feed recently eaten appears to cause a greater degree of deterioration than that which has been partially digested. Bacteriological studies have shown that the stomach portions of the digestive tract are sterile when free from feed, even when digestion in the intestines is incomplete. By the time feedy fish reach the cannery they have deteriorated to such an extent and are so badly broken that a large percentage is entirely unfit for packing.

In the French sardine industry(27), where bait is employed in catching the fish, the strictest attention is given to the quality of the bait in order to avoid decomposition in the fish. As late as 1853 the use of a prepared bait containing especially powdered prawn and shrimp was forbidden by royal decree, as it was held that it spoiled the fish by facilitating decomposition. In this connection it is interesting to note that the bacteria found associated with the feed (p. 24) were capable of decomposing fish tissue. One of these organisms forms spores which resist drying but are capable of growth and reproduction when conditions again become favorable. The bait mentioned, prepared from dried shrimp, doubtless contained the spores of this organism (Walfischrauschbrand) which was responsible for the decomposition of the fish.

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[1] Identification of specimens made by the Division of Marine Invertebrates of the U. S. National Museum.

In the preparation of anchovies, "Appetitsild," and "Gabelbissen," an extensive industry in Germany(28), the importance of using fish from which the feed has been eliminated is recognized. Practically all the fish used in the German industry are imported from Norway, where whole schools at a time are caught in powerful purse seines. The fish are kept in the seines for one to several days that they may free themselves of partly digested food, after which they are shipped to Germany in large hogsheads containing weak pickle.

The Maine sardine canners regard seined fish as inferior for packing on account of their excessively feedy condition. At times weir fish contain as much food as seined fish, but, owing to the necessity of taking fish under conditions existing at the time these investigations were made, the inferiority of such fish is overlooked and feedy weir fish are used.

ELIMINATION OF FEEDY FISH.

The solution of the difficulty experienced with feedy fish is comparatively simple. It can be accomplished by allowing the fish to remain in the water long enough to digest the feed contained in their alimentary tracts, which may vary from over one tide, 6 hours, to 12 or 18 hours, depending on the quantity of feed present. The fishermen and boatmen can readily determine when the fish are free from feed. For this purpose "pounds" or "pockets" (Pl. I, fig. 2) are attached to the weirs. A pound is practically a second weir adjoining the weir proper with a drop net between the two. The feedy fish are seined or driven into the pound, and held there for the requisite period. Doubtless a few weirs are situated where the water is so deep and the tidal currents so strong that it would be impossible to build pounds next to them. In such cases the fish may be held in the weirs. This is not, however, considered a good practice from the fisherman's point of view, as the use of the weir for holding a catch over one or two tides deprives them of the opportunity of catching fish at the succeeding tides. At most weirs, pounds can be built with the same ease as the weir itself.

A concerted demand on the part of the packers for fish free from feed will make it only a question of time before practically all of the weirs will be provided with pounds. This would improve the quality of the pack by eliminating "feedy" fish, provide a more uniform supply of fish, place the purchasing of fish and the boating on a sounder basis, and help to eliminate the taking of quantities of fish in excess of the capacity of the cannery, thus reducing one great form of waste.

Another solution of the "feedy" problem is to cut and eviscerate the fish before beginning the canning process. Thus the feed and viscera, which harbor the bacteria producing spoilage, are removed before an advanced stage of decomposition has been reached.

SWELLS.

During the latter part of the season of 1913 reports reached the laboratory of trouble due to swells at a few of the canneries on the west coast. No cause for this condition could be found by those in charge of the canneries, and, in spite of all the precautions taken, it increased each year, until it was estimated that as much as 30 per cent of the pack of one or two factories had swelled during the season. Canners in other localities reported that they had about 1 per cent of swells in a season's pack, though more were found in some seasons than in others. As it was felt that more trouble was due to swells than the majority of the packers were willing to admit, a special investigation was undertaken to determine the cause.

At the close of the sardine packing season of 1913, an investigation on the canning of clams was made at the Eastport laboratory during which gas-producing, facultative anaerobic bacteria were found in canned clams processed under commercial conditions.[1] A temperature of 240° F. was required to destroy the spores of this organism, which suggested the possibility that this organism, or one of similar nature, might be responsible for swells in sardines.

It was first planned to carry on the experimental part of the work at local points reporting the greatest number of swells. After the work was under way, however, statements from canneries along the whole coast indicated that the trouble was more general than at first supposed. In one case a canner reported that a large percentage of goods stored in his shipping room were "swells." Another canner reported the finding of a large quantity of "swells" in a shipment made by boat to the Pacific coast. The reports in these cases were accompanied by samples of the "swelled" goods. Bacteriological examinations of cans received from these canneries, as well as of cans of swelled sardines secured from packers which would be fairly representative of the whole Maine coast, showed the presence of an anaerobic organism in pure culture. It was then decided to extend this part of the investigation to the entire coast.

The bacteriological part of the work was begun during the late fall of 1915 and continued during the early fall of 1916. As it progressed it became apparent that the organism that was being studied as a cause of swelled cans was also probably responsible for the decomposition of the feed of herring, and, therefore, indirectly for the characteristic belly breaking of feedy fish. A more extensive study, including both chemical and bacteriological work, was therefore conducted during the early fall of 1916.

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[1] Unpublished reports in the Bureau of Chemistry.

BACTERIOLOGY OF THE FEED OF HERRING AND ITS BEARING ON SWELLS IN CANNED SARDINES.

In other investigations that have been made on swelled canned sardines the relation of the bacteria associated with the feed to the swelling of canned sardines has not been considered. Thus Cathcart(5) gives the results of the bacteriological examination of swelled cans of sardines. All the cans examined emitted gas when they were opened. The contents had an extremely bad odor, but were normal in appearance. Four different organisms were isolated, one of which was found to be *Bacillus coli.* Injections made intraperitoneally into guinea pigs of cultures of the unidentified organisms proved two of them to be pathogenic, while the third, seemingly, had no effect. In a bacteriological study of swelled sardines canned in Maine and New Brunswick, Sadler isolated eight strains of gas-producing bacteria from the swells examined(25). Very complete detailed descriptions of the cultures and organisms found, including biochemical reactions and morphological and biological features, are given in Dr. Sadler's report.

A very brief summary of the bacteriological studies made during this investigation upon the feed and upon swelled cans of sardines, both native and imported, is given here.[1] No aerobic bacteria were found, but *Bacillus Walfischrauschbrand,*[2] a rapid spore former, was isolated in pure culture. This organism was traced through the gills and stomach contents of the fish to the bodies of the live schizopods, usually in the thoracic region, and to the masses of copepods. It produced gas in the dead fish by its decomposition of the feed within the digestive tract.

During the investigation another organism was isolated, first from the stomach contents of a fish ready to be packed and later traced to the massed copepods fresh from deep-sea water. This organism, designated as *Bacillus B.*, was pathogenic to mice and guinea pigs and capable of producing a chemical decomposition similar to that produced by *B. Walfischrauschbrand.* It did not form spores, however, and was therefore much less resistant to heat. The *Bacillus Walfischrauschbrand* lived through the processing of the sealed cans whenever the temperature of the bath was slightly below the boiling point and when cans floated or protruded above the surface of the water.

Samples of various portions of the bodies of many herring were cultured anaerobically and aerobically. The flesh was invariably free from bacteria when the fish were removed from the weirs.

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[1] The bacteriological work was conducted by M. M. Obst, of the Bureau of Chemistry(21).

[2] *Bacillus Walfischrauschbrand* is the name applied by Nielsen(20) to the organism found in whales made sick by being shot with arrows previously inoculated with material from dead whales. The practice of shooting with such arrows was employed in certain whale fisheries at that time. The animal was easier to harpoon and land by this method.

The gills and digestive tract harbored bacteria as long as feed was present, but apparently as soon as all feed and waste products were eliminated these portions freed themselves of bacteria. Portions of cod, rockfish, bass, and alewives were also examined. The alewives alone were obtained with no feed present, and out of 72, 47 contained neither feed nor bacteria. *B. coli* and *B. Walfischrauschbrand* were isolated from the cod. The flesh was free from bacteria in practically every instance.

CHEMICAL COMPOSITION OF THE FEED OF HERRING.

The crustaceans, to which group of sea life the feed of the sea herring belong, differ in composition from meats and fish in having a large proportion of the carbohydrate glycogen present in the liver. This is suggestive in connection with the rapid formation of gas observed in decomposing feed, such as schizopods and copepods. Undoubtedly the composition of the feed is of such a nature as to furnish an excellent medium for the growth of gas- and nongas-producing bacteria.

In an investigation of the chemical composition of plankton, K. Brandt(4) obtained the following results on analyzing material which consisted almost entirely of copepods:

TABLE 5.—*Chemical composition of copepods (dry basis) (Brandt).*

	Per cent.
Protein	58.80
Fat	7.40
Carbohydrates (by difference)	22.88
Ash	10.92
Composition of ash:	
Silica (SiO_2)	2.31
Common salt (NaCl)	1.49
Other salts	7.12

He found the composition of the dry substance of copepods, which included varieties taken from fresh water, to be as follows:

TABLE 6.—*Average composition of copepods (dry basis) (Brandt).*

	Per cent.
Protein	59.0
Chitin	4.7
Fat	7.0
Carbohydrates	20.0
Ash	9.3

The results of the chemical analyses, made during this investigation on the feed of the sea herring, to determine the rate of decomposition are given in Table 7. The total volatile nitrogen, ammonia, and amines were determined as the indices of decomposition when the feed, copepods, and schizopods were allowed to spoil under the most favorable conditions in an incubator. The determination of the total volatile alkaline material in a catch of plankton, which consisted almost entirely of diatoms, is also given. The rate of decomposition of fresh-water herring is included for the sake of comparison with the rate of decomposition of the feed alone.

In each case as many determinations were made as were possible with the amount of material at hand, which was not often large because of the difficulty of obtaining any kind of feed unless the water was very quiet. The amount of total volatile nitrogen found before incubation was so small that it seemed unnecessary to determine amine nitrogen.

TABLE 7.—*Ammonia and amines per 100 grams in feed of sea herring.*

Feed.[1]	When taken.			Held in incubator.								
				24 hours.			48 hours.			72 hours.		
	Total.	Ammonia.	Amines.	Total.	Ammonia.	Amines.	Total.	Ammonia.	Amines.	Total.	Ammonia.	Amines.
	Mg.	*Mg.*	*Mg.*	*Mg.*	*Mg.*	*Mg.*	*Mg.*	*Mg.*	*Mg.*	*Mg.*	*Mg.*	*Mg.*
Plankton from Woods Hole, Mass., kept at 30° C. (chiefly diatoms)	2.82	......	......	......	......	......	......	......	......	4.14	......	......
Plankton from St. Croix River off Campobello Island (chiefly copepods)	6.04	......	......	......	......	......	......	......	......	402.2	......	......
Copepods from east and south of Campobello Island	3.94	......	......	272.4	206.2	66.2	468.2	375.1	93.1	......	......	......
Copepods from shallow water east of Grand Manan	......	......	......	216.6	153.8	62.8	......	......	......	......	......	......
Copepods from north end of Grand Manan in very deep water	9.50	......	......	191.7	143.4	48.3	296.8	260.9	35.9	......	......	......
Schizopods from Wilson's Beach Island, off Campobello	1.98	......	......	......	......	......	......	......	......	822.9	602.3	220.6
Schizopods from Wilson's Beach Island, off Campobello	3.95	......	......	220.4	88.2	132.2	787.6	573.7	213.9	1009.2	832.6	176.6
Feed taken from belly-blown fish at wharf, Eastport, Me	37.7	17.1	20.6	......	......	......	......	......	......	......	......	......
Fresh-water herring from Taunton River, Taunton, Mass	9.94	......	......	127.0	111.6	15.4	......	......	......	888.3	812.6	75.7

[1] Samples were kept at incubator temperature (37.5° C.).

Both ammonia and amines in very large quantities were found in the decomposing feed, schizopods and copepods. When allowed to spoil under these conditions and to the extent that took place during a period of from 48 to 72 hours, ammonia was found in much larger amounts than amines. From the limited number of determinations it was possible to make it was apparent that little difference, if any, exists in the rate of decomposition or in materials formed between copepods and schizopods. Considering the similarity of composition of the two forms, it is quite probable that no difference in degree or kind of decomposition would be found. The examination of the feed taken from the viscera of belly-blown fish gave results confirming those found under artificial conditions. Both ammonia and amines were present in appreciable amounts, the quantity of amines in this instance being in excess of the ammonia.

LABORATORY EXPERIMENTS WITH BACILLUS WALFISCHRAUSCHBRAND AND BACILLUS B.

To establish more firmly the conclusion that the decomposition of the feed and of the fish, resulting in the condition termed belly blown, is due to the presence of *Bacillus Walfischrauschbrand* and *Bacillus B*, found in great numbers in the samples of feed and swelled cans examined, and to show that the presence of these bacteria is indicated when volatile nitrogen bases are found in belly-blown fish, swelled cans, etc., these bacteria were grown in pure culture upon a medium containing fish protein, and the products resulting from their growth observed. The fish used for cultures 24, 25, 31, and 32 (Table 8) were fresh Boston mackerel. Fresh-caught Potomac bass were used for cultures 27, 28, 29, and 30. After removing the skin, solid masses of meat were passed through a meat grinder and mixed with a solution of dextrose of such strength that the final mixture, of a uniform paste consistency, contained 0.2 per cent of dextrose. The whole was then sterilized under 15 pounds pressure. Portions of this paste were inoculated with 24-hour-old dextrose agar anaerobic cultures of the bacteria, and covered with an inch layer of sterilized fish broth made firm with 1.5 per cent agar and no nutriment, and then incubated at 37½° C. until removed for analysis. Whenever a sample was removed for analysis, the presence of the bacterium with which it had been inoculated was determined positively.

TABLE 8.—*Ammonia and amines in pure cultures of Bacillus Walfischrauschbrand and Bacillus B grown in the laboratory.*

Bacteria and culture No.	Period of incubation.	Total volatile alkaline material as—					Nitrogen by amino acid method as nitrogen per gram.[1]	Alkalinity (0.05 N. acid per gram).
		Nitrogen per 100 grams.			Percentage of total.			
		Total.	Ammonia.	Amines.	Ammonia.	Amines.		
Sterile:	*Days.*	*Mg.*	*Mg.*	*Mg.*	*Per ct.*	*Per ct.*	*Mg.*	*Cc.*
30	7	18.5	....	....	....	....	0.55	0.0
B. Walfischrauschbrand:								
28	2	259.5	215.2	44.3	82.9	17.1	5.34	....
28	4	....	....	....	....	....	5.65	....
31	7	510.1	447.1	63.0	87.7	12.3	9.95	2.1
32	7	334.6	286.2	48.4	85.6	14.4	5.16	1.5
Bacillus B:								
24	2	146.8	....	....	....	....	....	1.2
24	4	208.4	160.3	48.1	76.9	23.1	....	1.9
25	3	159.1	127.7	31.4	80.3	19.7	....	....
29	2	145.8	132.6	13.2	81.0	9.0	2.52	....
27[2]	2	225.2	198.8	26.4	88.2	11.8	5.07	....
27	3	....	....	....	....	....	5.59	....

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[1] These determinations were made by the latest amino acid method and apparatus. Van Slyke (J. Biol. Chem. (1913) 16:121).

[2] A few micrococci in this culture.

The results in Table 8 show that both ammonia and amines are formed when *Bacillus Walfischrauschbrand* and *Bacillus B* are grown in pure culture on fish media. Under the conditions which obtained when these experiments were made, amines are formed in smaller amounts than when the different lots of feed are decomposed at incubator temperature. It would appear that a larger proportion of amines are formed during the decomposition of the feed and the fish under natural conditions.

In the cultures of *Bacillus Walfischrauschbrand* and *Bacillus B* used for the determination of ammonia and amines, positive tests for both indol and skatol were obtained. These results confirm those shown in Table 7—that ammonia and amines are produced by these organisms during the decomposition of the feed.

Cause of Belly-Blown Fish.

The fact that the bacteria found with the feed and in feedy fish decompose fish tissue, elaborating the same end products of decomposition as when the viscera and contents of herring decompose, points clearly to the cause of the condition of the fish termed "belly blown." It was shown (p. 86) that when the stomach and intestinal tract of the fish are empty, or practically so, no bacteria are present. The bacteria associated with the feed are eliminated with the digested feed or destroyed during the process of digestion. Only when the stomach or intestines contain feed in an undigested or partially digested condition are these bacteria found in abundance. Their growth during these conditions, when the fish are dead, gives rise to the products of decomposition. At certain times during the prevalence of feed a large proportion of the fish on flakes just taken from the steam boxes have been seen with the belly portions ruptured in a manner suggesting an explosive bursting. Small amounts of gas often were found lodged in some portion of the digestive tract when the gas-producing organiam was also present. When occurring in sufficiently large amounts, the rapid expansion of this gas during the steaming process may cause the rupturing of the partially digested and weakened tissues surrounding the viscera. From this the term "belly blown" undoubtedly originated.

As the decomposition in the viscera and contents progresses bacteria are carried into the surrounding tissues, which are rendered soft by the alkaline materials, ammonia and amines. The thin belly portion of the fish is disintegrated by the action of the bacteria, and as decomposition progresses this portion of the fish gradually sloughs away, producing the characteristic ragged appearance termed "belly blown" (Pl. XVIII). The rapidity with which this condition is brought about depends upon the extent to which the fish are gorged with feed and the kind of bacteria accompanying the feed. Several lots of fish which contained feed when taken from the water showed, on reaching the canneries, an actual loss of 85 per cent due to belly-blown fish. A 25 to 50 per cent loss is not uncommon when feedy fish are taken. It is impossible to mistake the characteristic appearance of belly-blown feedy fish before or after packing.

TRANSPORTATION OF THE FISH.

A series of experiments were made to determine, both by chemical analysis and physical examination, the rate at which the fish decompose during transportation and their fitness for packing after being transported under different conditions. As a measure of the decomposition the total volatile nitrogen (ammonia and amines) was the only determination made.

The fish were carried in the hold of a small sardine boat, in a large hogshead, approximately 3½ feet at its greatest diameter by 4 feet deep, provided with a wire screen to serve as a well, extending from the top to the bottom, through which the water and pickle could be pumped. Samples were taken as the fish were removed from the water and at 2- to 4-hour intervals thereafter, up to 24 and 30 hours. In one case samples of fish which had stood for 50 hours were examined. The samples that were taken during transit were placed in screw-cap Mason jars, which were kept in a mixture of salt and ice. They were frozen by this method, and were thus preserved until analyzed. At the laboratory the fish were cut and eviscerated, and samples made of the flesh and of the intestines and contents. A separate analysis was made of each.

Fish Carried in Bulk Without Salt.

Two lots were studied to determine the effect of transporting the fish in bulk without salt. The water dipped up with them was not drained off from the first lot. It was, however, pumped off from the second lot shortly after placing the fish in the hogshead, and at regular intervals thereafter. Five tubs of small fish, 4 to 5 inches in length and weighing 625 pounds net,[1] composed the first lot.

The first four samples (Table 10), which were taken at 2-hour intervals, represent conditions while in transit, whereas the sample taken at the end of 20 hours represents conditions while the fish were lying at the wharf overnight. The temperature of the fish in the middle of the hogshead at the time the 20-hour sample was taken was 54° F. The fish of this lot seemed to be in good condition when landed after the 5-hour run. At the end of 20 hours they had begun to soften, and some water had collected. A sample of this water, weighing 2 pounds, was taken at the end of 20 hours and also at the end of 24 hours. At the end of 24 hours the fish and water had an odor of decomposition, particularly the water, which had not been pumped off during transit. Unfortunately, some of the water had leaked out of the hogshead during the night, but the amount pumped off, together with an estimate of that lost through leaking, made approximately 50 pounds of water collected from this quantity of fish standing 24 hours.

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[1] This weight included about one-half of the water dipped up with the fish and not drained off. In the ordinary practice of loading the boats at weirs, the water does not completely drain from each tub of fish. The only drainage is through a number of half-inch holes in the measuring tubs while the tub is being filled.

The figures in Table 10 show plainly the rate of decomposition. The viscera and contents deteriorated somewhat during the 4- to the 6-hour period. At the end of the 20-hour period the content of total volatile nitrogen was just double that found at the end of the 6-hour period. Some decomposition was also evident in the flesh of the eviscerated fish at the end of the 6-hour period, while at the end of the 20-hour period marked decomposition had occurred. In the analysis of the viscera and contents and of the flesh, samples taken from the bottom of the hogshead showed more decomposition than samples collected from the top of the hogshead. These results indicate that the viscera and contents deteriorate more rapidly than the flesh of the fish, and that no very marked deterioration in the flesh occurs during the five hours of transportation. Subsequent bacteriological studies showed that the flesh of the fish was sterile or, at most, contained but few bacteria. Bacteria were very frequently found in the contents of the viscera. Decomposition would naturally occur in the viscera and contents before penetrating to the flesh.

Five tubs of fish, weighing 628 pounds, were used in the second lot. The tubs of fish were allowed to drain thoroughly before being weighed; consequently but little water was present. After allowing the fish to stand in the hogshead for a few minutes, 1½ buckets, weighing 25 pounds, of water were pumped off. The fish were brought to the laboratory after a 2-hour run and sampled every two hours, up to and including 12 hours, during the day while lying at the wharf. A sample was also taken the next morning at the end of 24 hours. After standing for 6 hours the water was pumped off and found to weigh 24 pounds. At the end of 12 hours an additional 9½ pounds of water was pumped off. After standing over night, or at the end of 24 hours, 7½ additional pounds of water had formed. The total amount of water obtained in 24 hours was 40.6 pounds. The water pumped off during the first 6 hours had but a slight color; at the end of the next 6-hour interval it was blood red; and at the end of the next 12-hour interval it was decidedly bloody. Both the 12- and 24-hour specimens precipitated a quantity of protein from test portions.

When landed at the laboratory 2 hours after being taken from the weir these fish appeared to be in as good condition as when they were taken aboard. They had settled a little in the hogshead, becoming more solid and compact. So far as the physical appearance would indicate, they were in good condition up to and including the 6-hour period. At the end of 8 hours they had changed slightly, while 2 hours later a slight odor was noticeable in the hold of the boat and the fish seemed a trifle soft. After 12 hours had elapsed this softness was more pronounced, and the bellies of some of the fish were broken. At the end of 24 hours, although there was no decided odor of decomposition, the fish were soft and spoiled and the bellies of a number were broken. The fish on the top of the load had lost their luster ("bloom") and taken on a dead whitish color, while those from the bottom were in worse condition, being badly broken and pressed out of shape by the mass above. Such fish were quite unfit for packing. The temperature of the fish in the hogshead at the end of the 6-hour period was 51° F. The temperature of the water in the bay at this time and during the time the fish lay at the wharf was 50° F.

The analyses of samples from this lot of fish show at the end of the 6- and the 8-hour period a sufficient increase in the amount of volatile nitrogen in the viscera and contents over that found in the fresh fish to indicate a slight decomposition. At the end of the 12-hour period the decomposition in the viscera and contents was marked, although there was no visible evidence of decomposition in the flesh. At the end of the 24-hour period, however, marked decomposition was shown in the flesh as well as in the intestines and contents.

In this experiment the fish at the top of the load did not differ in amount of decomposition from those taken from the bottom of the pile. In this shipment the water was pumped off at intervals, whereas in the preceding experiment it was not. Evidently this drainage water tends to increase the rate of decomposition of the fish at the bottom of the mass from which it has not been removed, or, as might be expected, larger quantities of volatile nitrogen occur in fish standing in water drained from fish undergoing decomposition.

Fish Carried in Bulk, Salted at the Rate of One-Half Sack per Hogshead.

In this experiment five tubs of fish, weighing 649 pounds, were employed. On being loaded, the fish were evenly salted at the rate of one-half sack per hogshead. The water dipped up with the fish was drained off and the pickle formed during the experiment pumped off at 2-hour intervals, with the exception of the 10-hour period. This pickle was weighed, sampled, and analyzed (Table 9).

TABLE 9.—*Composition of pickle formed during transportation of fish in salt.*

Time of forming pickle.	Description.	Weight.		Specific gravity.	Salt (NaCl).	Nitrogen.
Hours.		*Pounds.*	*Grams.*		*Per cent.*	*Per cent.*
2	Very light, slight yellow color, clear	29.5	13,409	1.155	19.93	0.072
4	Light in color, with slight reddish tinge, clear	22.5	10,227	1.145	18.55	.134
6	Slightly reddish in color, slightly cloudy	9.0	4,090	1.140	17.68	.178
8	Reddish, cloudy	4.5	2,045	1.140	17.14	.206
12	Reddish, more cloudy than that held 8 hours	4.21	1,912	1.130	15.86	.245
25	do	11.0	5,000	1.110	12.44	.330

Attention is directed to the decrease in the specific gravity and corresponding decrease in the percentage amount of salt, and to the increase in the percentage of nitrogen during each succeeding interval that the fish remained in salt.

At the end of the 2 hours required for the run to the laboratory all the fish had "struck," and at the end of the 4- to 6-hour period, they had begun to show the effects of salting, although still in fair condition. At the end of the 8-hour period they were hard and firm, and some showed the thin, pressed appearance characteristic of fish which have been carried too long in salt. The bellies of very few were broken at the end of 8 hours. Compared with the standard for quality obtaining at the time these experiments were made, they would at this period have been considered good fish for packing. The same can be said for them at the end of the 10-hour period, except that the shrunken and shriveled appearance had become more pronounced.

While the determination of total volatile nitrogen (ammonia and amines) is not a true criterion upon which to base decomposition changes taking place in the flesh of fish carried in salt, since the decomposition products formed, particularly ammonia and amine, pass into the brine, it is none the less interesting to note that the volatile nitrogen content of the flesh gradually diminished during the time the fish were in salt, up to and including the 12-hour period, rising noticeably after the fish had been held for 25 hours and again at the end of 50 hours. At the end of the 4-hour period the amount of ammoniacal materials in the viscera and contents of the fish carried in salt had increased appreciably.

In contrasting this experiment with the preceding experiment it is apparent that the viscera and contents of this lot decomposed a little more rapidly than those of the fish carried without salt. While this may be due, in part at least, to the difference in the quantity or quality of the food in the intestines of the fish comprising these lots, it serves to show that the salting of fish does not prevent deterioration during transportation to the extent generally supposed. In an investigation on the conservation of fish and meat products with salt, Pettersson(22) found that anchovies and similar preparations always contain numerous cocci, rods, and yeasts as bacterial flora. Apparently, therefore, certain forms of bacteria survive the excessive salting given such products. Table 10 shows that a little over 3 per cent was the maximum quantity of salt found in the flesh, viscera, and contents of fish subjected to the ordinary salting or pickling process—not a sufficient amount to retard bacterial growth. In fact, a media containing 3.33 per cent salt was found to be the most favorable for the growth of bacteria common to this region.

This experiment proves also that the analysis of the viscera and contents may be taken as a very good indication of the time and the rate at which the fish deteriorate, and that the intestines and contents show decomposition in greater quantity at an earlier period than does the flesh. Another interesting point brought out in these experiments is the fact that decomposition extends to the flesh of fish held in salt for an excessive length of time.

FISH CARRIED IN COMPARTMENTS, SURROUNDED WITH ICE AND SALT MIXTURE.

This shipment was made at the same time as the one in the preceding experiment. Two tubs of fish, weighing 294 pounds, from the same catch were used. The fish were equally divided among the five compartments of the box designed to carry them, and completely surrounded with ice and salt mixture. They were not piled over 5 or 6 inches deep. A hole in the bottom of the hogshead in which the box was placed allowed the drainage to pass into the hold of the boat. The temperature of the iced fish in the third compartment from the top, after 12 hours, was 3° C. (37.4° F.). After 25 hours' standing the temperature in the third and fourth compartments was 1½° C. (34.7° F.), and after 30 hours the temperature reached $-1°$ C. (30.2° F.). Some of the ice and salt had melted, about one-fourth of the total quantity used remaining at this time.

These fish remained firm and plump, even after standing 25 hours. They did not have a leached-out appearance, but were of a brighter and better color than those which had been carried in the salt. When the samples were being prepared for analysis, the iced fish looked like fresh fish. At the end of 6 hours, however, a difference was noted in the appearance of the gills which were not as bright a red as those of fresh fish. The fish retained their freshness of color and consistency of flesh throughout the time they were kept. Even at the end of 50 hours, in spite of the fact that they had deteriorated to such an extent as to be unfit for packing, they had a better appearance than those which had been kept in salt. At the end of 12 hours the fish surrounded with ice were in splendid shape, still firm and plump, although they had lost the stiff, rigid condition shown previous to this time. At the end of 25 hours a few fish in both lots (in salt and in ice) showed broken bellies, but one lot had no more belly-broken fish than the other. At the end of 50 hours the iced fish were quite soft and the bellies of a few more were broken, but no more than in the case of the salted fish, which were harder and firmer in texture, though much poorer in appearance, suggesting a poor quality of salt fish.

The analyses of the samples from the lot of iced fish, which were taken at intervals of 4 hours, up to and including 12 hours, and at 25, 30, and 50 hours, indicate that the viscera and contents of the fish kept without appreciable evidence of decomposition up to and including 12 hours. At the end of 25 hours a slight decomposition was indicated, which was more noticeable at the end of 30 hours. At the end of 50 hours, decomposition of the viscera and contents was quite marked. Under the conditions of this particular experiment, practically no decomposition took place in the flesh of the eviscerated fish. It is probable that the slight evidence of decomposition obtained after 50 hours standing in excess of that found in the fresh fish represents the slight deterioration that might be expected in fish kept under these conditions.

TABLE 10.—*Changes in composition of fish when transported under varying conditions.*

Condition of fish.		Viscera and contents.				Flesh of eviscerated fish.			
Out of water.	In dry salt.	Water.	Fat.	Salt (NaCl).	Total volatile nitrogen (N) per 100 grams.	Water.	Fat.	Salt (NaCl).	Total volatile nitrogen (N) per 100 grams.
Hours.	*Hours.*	*Per cent.*	*Per cent.*	*Per cent.*	*Mg.*	*Per cent.*	*Per cent.*	*Per cent.*	*Mg.*
Lot 1 (no salt):									
Fresh	....	66.70	19.12	....	11.6	76.00	4.39	....	9.3
2	....	66.72	19.67	....	....	76.64	3.65	....	....
4	....	59.97	28.07	....	11.6	74.70	5.34	....	9.3
6	....	66.40	20.05	....	16.3	76.37	4.34	....	14.0
20	....	65.41	24.08	....	32.6	76.92	4.43	....	21.0
24 [1]	....	54.23	36.99	....	....	75.23	5.02	....	21.0
24 [2]	....	60.60	[3] 28.94	....	37.3	74.86	5.38	....	28.0
Lot 2 (no salt):									
Fresh	....	62.40	21.75	....	12.6	74.44	4.91	....	13.0
2	....	60.55	19.57	....	11.7	75.68	3.42	....	13.5
4	....	63.53	24.14	....	14.0	76.96	3.90	....	13.8
6	....	63.63	23.85	....	15.0	76.78	3.92	....	14.0
8	....	64.73	22.91	....	17.7	76.58	3.68	....	14.0
10	....	62.29	26.15	....	17.7	76.42	4.03	....	10.7
12	....	63.41	24.65	....	22.3	77.01	3.88	....	14.5
24 [1]	....	65.60	21.17	....	39.1	76.65	3.30	....	24.2
24 [2]	....	71.82	[3] 12.94	....	38.2	77.26	4.53	....	23.3
Lot 3 (½ sack salt per hogshead):									
....	Fresh.	62.33	24.62	0.41	11.0	76.18	4.40	0.21	14.0
....	2	59.45	26.62	1.22	12.1	71.26	4.99	2.41	10.8
....	4	56.70	26.84	2.18	18.2	69.49	6.03	2.98	8.8
....	6	56.86	27.68	1.75	18.2	70.89	5.51	2.29	8.0
....	8	59.67	23.97	1.93	18.7	70.39	5.61	2.42	9.8
....	10	56.21	25.16	2.76	19.1	68.93	6.29	2.93	7.9
....	12	55.74	26.86	2.20	....	68.13	6.98	2.74	7.7
....	25	60.14	21.20	2.94	27.6	67.22	6.14	3.69	11.5
....	50	59.74	26.85	1.59	38.0	71.24	5.19	1.95	17.9
Lot 4 (kept cold with mixture of ice and salt):									
Fresh	....	62.33	24.62	....	11.0	76.18	4.40	....	14.0
4	....	57.23	37.75	....	14.9	75.99	4.35	....	12.2
8	....	62.02	27.66	....	17.2	74.87	3.63	....	7.9
12	....	56.03	36.54	....	16.3	75.86	5.33	....	9.8
25	....	61.20	28.71	....	18.6	76.22	4.60	....	10.3
30	....	62.46	26.15	....	19.6	75.64	5.04	....	11.0
50	....	67.84	20.10	....	33.2	76.85	3.63	....	16.3

[1] From top of load.

[2] From bottom of load.

[3] Shows effect of pressure.

These experiments show that as a means of preservation in the transportation of the small sea herring, refrigeration is in every respect far superior to the use of salt. This is apparent from a comparison of the physical condition of the two lots of fish at the different intervals of time, and is confirmed by the analytical results. The same degree of decomposition in the viscera and contents of the fish carried under refrigerator conditions as that found for the 8- to 10-hour period in the case of the fish in salt is not shown until the end of from 25 to 30 hours.

The difference between the appearance of fish transported under refrigeration and that of those carried an excessive length of time in salt is shown in Plates XII and XIII. Kept in compartments surrounded with ice and salt they are plump and firm, and look like fresh fish, even after they have been 30 hours out of water. The fish carried an excessive length of time in salt, in bulk, are poorer in appearance, and much thinner, and have been pressed out of shape. Each lot of fish at the time of capture varies in the amount and kind of food in the digestive tract, and also in the bacterial contamination of the digestive tract. The keeping qualities, or the rate of decomposition, of different lots of fish should therefore vary directly as the contamination and quantity of feed vary. That this is true is shown by the differences in the time and extent of spoilage of the various lots of fish employed in these experiments.

TEMPERATURE CHANGES OCCURRING IN LOADS OF FISH DURING TRANSPORTATION.

Temperature observations were made on boatloads of fish transported from the weirs to the canneries in pickle and in dry salt. It was estimated that the fish in the three lots studied contained different proportions of feed. The results are given in Table 11. The temperature measurements were accurately made by means of a Leeds and Northrup potentiometer, the thermocouple of which was inserted in the mass of fish in the boats, and readings taken at the time intervals indicated. The temperature changes of the air on the warmest day of the month and the changes shown from the mean temperatures for the month in which these observations were made are included in the table.

TABLE 11.—*Temperature changes in loads of fish during transit.*

FLOATED IN BRINE CONTAINING 150 POUNDS OF SALT PER HOGSHEAD OF FISH; SLIGHT AMOUNT OF FEED PRESENT.

Time observed.	Temperature. Of air.[1] Warmest day.	Temperature. Of air.[1] Mean for month.	Temperature. Of fish.
a. m.	° *C.*	° *C.*	° *C.*
6.30	12.7	6.9	12
7.00	....	....	13
7.30	....	....	15
8.00	13.8	8.2	16

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[1] From hourly thermograph readings taken from original monthly record of observations at Eastport, Me., for October, 1916 (courtesy of U. S. Weather Bureau).

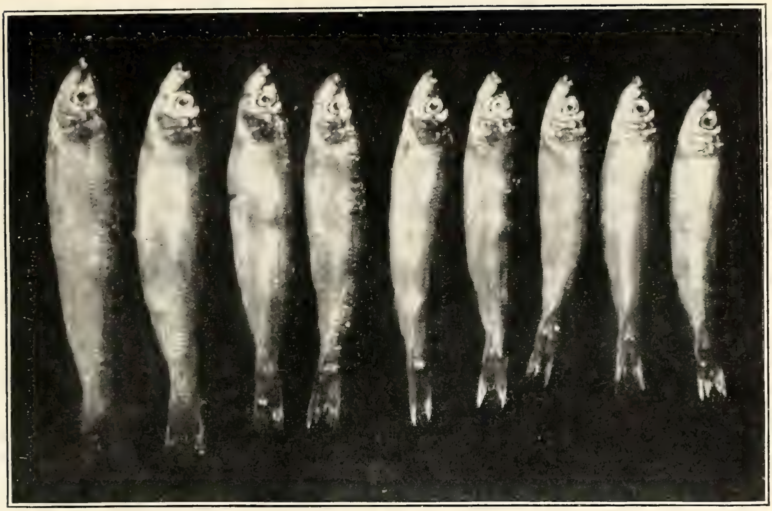

FIG. 1.—FISH CARRIED IN SMALL BULK, IN COMPARTMENTS SURROUNDED WITH ICE AND SALT.

No salt on fish. Fish out of water 30 hours.

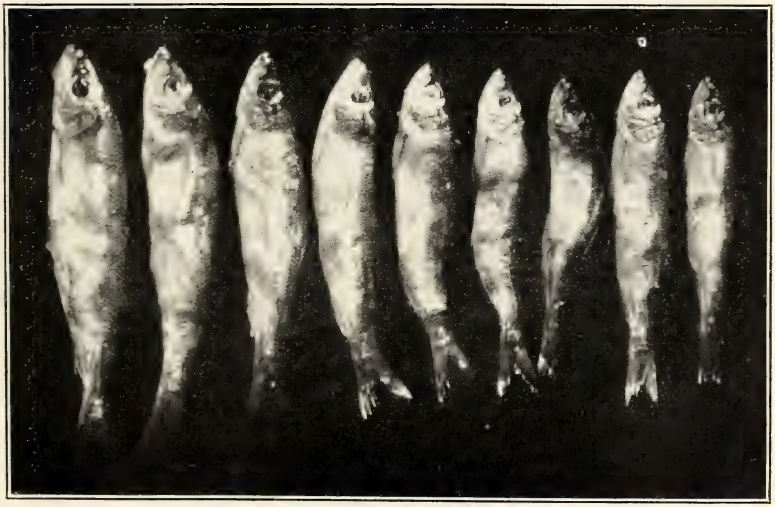

FIG. 2.—FISH CARRIED IN BULK IN SALT, ONE-HALF SACK PER HOGSHEAD.

Fish in salt 25 hours. Note effect of excessive salting and compare with iced fish 30 hours old, with no salt.

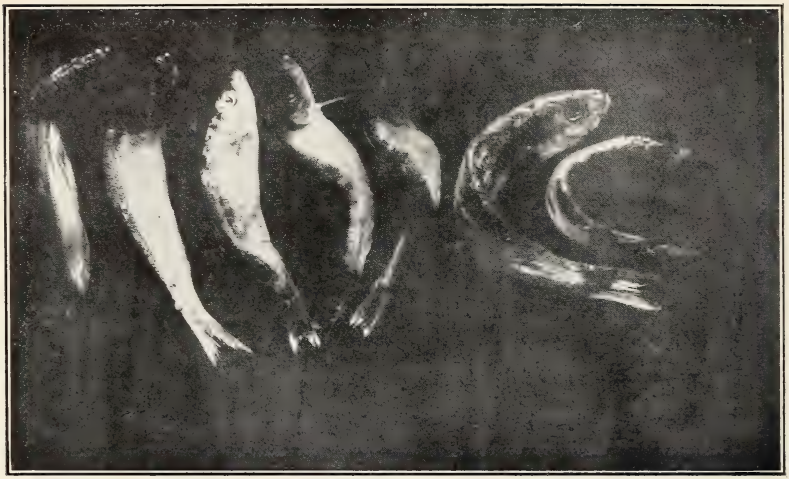

FIG. 1.—FISH EXCESSIVELY SALTED AND CARRIED IN LARGE BULK.

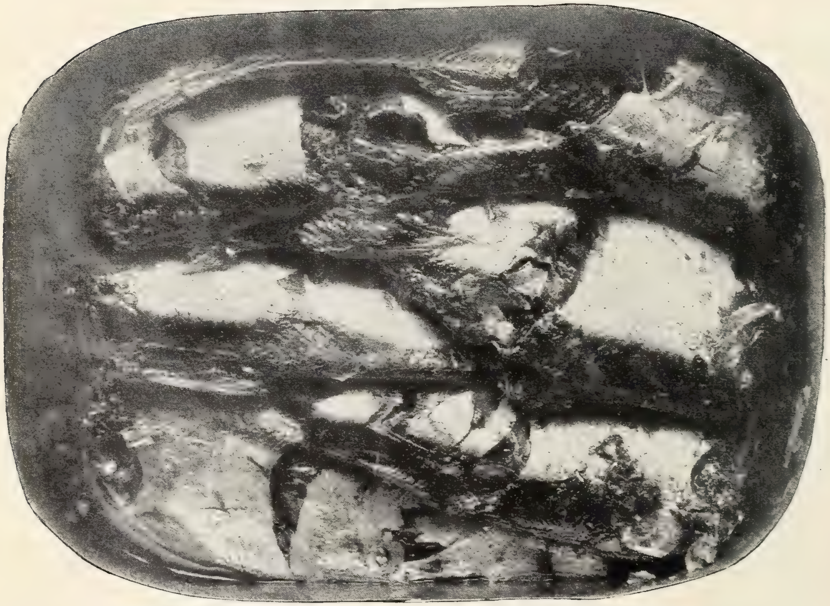

FIG. 2.—A CAN OF SARDINES SHOWING THE EFFECT OF EXCESSIVE SALTING OF THE FISH.

Note the transverse cracks and fissures on each fish. A portion of the side of one fish has been lost.

TABLE 11.—*Temperature changes in loads of fish during transit*—Continued.

DRY-SALTED, 150 POUNDS OF SALT PER HOGSHEAD; FISH 2½ FEET DEEP IN BOAT; 47 PER CENT OF FEED PRESENT.

Temperature.			
Time observed.	Of air.		Of fish.
	Warmest day.	Mean for month.	
a. m.	*°C.*	*°C.*	*°C.*
9.30	17.2	9.6	11
10.36			14
11.30			18
p. m.			
12.30	20.0	11.9	23.5

DRY-SALTED; 90 PER CENT OF FEED PRESENT.

a. m.	*°C.*	*°C.*	*°C.*
5.56	11.7	6.7	11
6.24			12
9.23			18.5
10.36			22
11.30			24.5
p. m.			
12.30	20.0	11.9	27
2.00	22.8	12.4	
4.20	20.0	11.1	37.5

The changes of temperature in the outside air were not sufficient to account for the changes in temperature which occurred in the loads of fish. It is evident that fish heat when carried in bulk, as is now the custom, the temperature increasing in proportion to the amount of feed present. The temperature of fish which contained but a small amount of feed and were carried in pickle rose 4° during one and one-half hours. That of dry-salted fish, estimated to be 47 per cent feedy, rose 12.5° during three hours. A boatload of fish in dry salt, 90 per cent of which were estimated to contain feed, rose 11° in temperature during a run of four and one-half hours. Just before the fish on this boat were unloaded, practically 10½ hours after they had been taken from the water, the temperature of the mass, taken midway between the top and bottom, showed an increase of 26.5°.

The rise in temperature of masses of fish in bulk is caused by decomposition changes due to bacterial growth, by far the greater part of which takes place in the viscera and contents. As the temperature of the mass of fish rises and approaches the optimum temperature favorable to bacterial growth, it is evident why the decomposition of feedy fish proceeds, at times, so rapidly. It is also evident why keeping the fish in smaller bulk and at a low temperature markedly retards this decomposition.

CONCLUSIONS.

It is not necessary to salt excessively fish which are to be in transit for a reasonable length of time only. Since excessive salting does not prevent completely the decomposition of fish, salt should be used in transit with the idea of saving time in the pickling sheds rather than as a means of preserving the fish during transportation over great distances.

Fish preserved with salt should not be transported over a distance requiring more than 6 hours to cover. Sometimes 4 hours is the limit.

Where practicable it would be desirable to install some method of refrigeration on all boats used to haul the fish for long distances. Boats thus equipped not only greatly extend the fishing radius, but also bring the fish to the canneries in a condition far superior to that of fish carried in salt.

The decomposition due to "heating," which was found to occur in large masses of fish during transportation, can be retarded by shipping them in small bulk at low temperature. Small compartments, permitting the circulation of cold air, are necessary in boats equipped with refrigeration devices.

PICKLING AND SALTING THE FISH.

In earlier days all the pickling was done after the fish reached the cannery, where an expert in this work was employed in the pickling shed. As a rule, the fish were held in strong brine or pickle, usually made to a strength of 90° on the salimeter, for about two hours, although the period of holding varied with the fatness of the fish, those which were fat needing more time for the process than the lean ones. The length of time was determined by the appearance of the fish, which were said to have "struck" when they had been long enough in the salt brine.

Within the past 12 or 15 years most of the boats transporting fish have been equipped with water-tight tanks in which salt or pickle may be added to the fish as they are taken from the weirs. Thus salt came into use as a means of preserving the fish during transportation. The use of salt during the trip prevents the extreme decomposition possible under the old methods of transportation, cuts down the time required for pickling at the canneries, and permits the carrying of the fish for greater distances. While fish obtained near the canneries still are salted or pickled in the sheds, those which are to be transported far are kept in salt or pickle. When transported for great distances no attention is paid to the length of time the fish are kept in salt or pickle. This excessive salting results in an inferior pack of sardines (Pl. XIII).

The time the fish remain in pickle or salt is a most important consideration in the packing of sardines. They should be kept there long enough to acquire the proper salt flavor, but no longer. As a rule, fish are salted sufficiently or excessively during the run to the cannery and need but little or no subsequent pickling. When they have been too long in dry salt, it is customary to hold them in weak pickle for a short time after they reach the factory, to remove the excess of salt before they are started through the process. Part of the salt also is removed when they are steamed (p. 47).

According to the best practice, the fish are not allowed to remain excessively long in pickle after they have reached the cannery, overnight, for example. Held in pickle for from 6 to 10 hours, they become soft, the bellies often breaking away, and they acquire a peculiar, dull, leached appearance. Held too long in dry salt the fish, particularly those that are small and lean, become dry, hard, and brittle, with a tendency to break transversely during the steaming and drying processes, in which case they are said to be "burned by salt" (Pl. XIV, fig. 2). Fish treated in either way are very undesirable for canning.

Since it is impossible to make even a fair grade of sardines from fish which have been excessively salted or pickled, it is essential that the canner should constantly guard against excessive salting and pickling of the fish.

In order to obtain information which would be helpful in carrying out this step of the canning process, an extensive investigation of the pickling and salting of fish was undertaken.

COMPOSITION OF SALT USED.

Salt used in pickling and salting fish is said to vary in effectiveness with its calcium and magnesium content, one of a low content penetrating the tissues of the fish better than those high in these constituents. Samples of three kinds of salt used in the Maine industry during 1913 and 1914 were analyzed, with the results shown in Table 12.

TABLE 12.—*Composition of salt used in salting and pickling the fish.*

Determination.	American.	Liverpool.	Trapani.
Moisture per cent	1.57	4.16	3.44
Insoluble in water do	.12	.17	.14
Calcium chlorid ($CaCl_2$) do	.94	.46	.87
Magnesium chlorid ($MgCl_2$) do	.09	.16	1.04
Sodium sulphate (Na_2SO_4) do	1.61	.76	1.42
Potassium chlorid (KCl) do	2.22	4.03	.40
Sodium chlorid (NaCl) do	93.48	90.33	92.49
Total do	100.03	100.07	99.80
Sodium chlorid (NaCl) on dry basis do	94.97	94.21	95.78

Each contained but a small amount of calcium and magnesium. The Liverpool salt showed the highest water content and lowest calcium and magnesium content, and the American salt the lowest water content and highest salt (NaCl) content. It had but little over 1 per cent of calcium and magnesium calculated as the chlorids. The Liverpool salt was used in the experimental work.

CHANGES OCCURRING IN FISH HELD IN PICKLE AND IN DRY SALT.

A number of experiments on a laboratory scale and on a comparatively large scale were conducted to determine what changes occur when fish remain for certain periods of time in pickle and in dry salt.

LABORATORY SCALE.

Fish about 5 inches long, said to have been out of the water only two hours, both eviscerated and uneviscerated, were used for the first series of experiments. They had been carried in pickle with a specific gravity of 1.1212 at 25°/25° C. and a salt content of 15.5 per cent.

Some of these fish, in covered porcelain evaporating dishes, were allowed to stand for some time in pickle obtained from a freshly prepared lot at an adjacent cannery. The composition of this pickle at the stated intervals is shown in Table 13.

TABLE 13.—*Composition of pickle in which fish were held.*

Condition.	From eviscerated fish.		From uneviscerated fish.	
	Specific gravity (by picnometer), 25°/25° C.	Salt (NaCl).	Specific gravity (by picnometer), 25°/25° C.	Salt (NaCl).
		Per cent.		*Per cent.*
Fresh	1.1279	16.49	1.1279	16.49
After 24 hours	1.1150	14.50	1.1099	13.56
After 48 hours	1.1152	14.49	1.1120	13.98
After 96 hours	1.1157	14.49	1.1132	13.97

TABLE 14.—*Composition of fish held in pickle and in dry salt (2 to 96 hours).*

Condition of fish.	Water.	Fat.	Total volatile nitrogen (ammonia and amines).	Moisture and fat free basis.		Acidity of fat (N/20 sodium ethylate per gram).
				Total volatile nitrogen (ammonia and amines).	Amino acid nitrogen.	
	Per cent.	*Per cent.*	*Mg.*	*Mg.*	*Mg.*	*Cc.*
Eviscerated fish in pickle:						
2 hours	69.68	4.36	16.3	62.8	1.53	12.3
24 hours	63.75	4.62	....	....	.96	12.6
48 hours	62.30	3.94	10.5	31.1	1.00	12.5
96 hours	67.39	3.69	7.0	24.2	1.00	10.7
Uneviscerated fish in pickle:						
2 hours	69.33	3.97	18.6	69.7	1.87	15.5
24 hours	63.22	5.86	13.9	45.0	1.68	14.6
48 hours	62.63	5.65	....	....	1.37	15.0
96 hours	68.25	3.77	12.9	46.1	1.34	16.9
Eviscerated fish in dry salt:						
24 hours	52.42	5.20	14.0	33.1	1.09	17.0
48 hours	52.68	4.85	12.8	30.1	1.00	16.7
96 hours	53.31	5.00	15.2	36.5	1.00	16.4
Uneviscerated fish in dry salt:						
24 hours	51.85	6.31	12.8	30.6	1.44	17.3
48 hours	50.58	6.01	13.9	32.0	1.03	17.1
96 hours	52.56	6.44	14.0	34.1	1.18	15.1

Other fish of the same lot, in enamel pans, were intimately mixed with salt until they were almost covered, when a final layer just covering them was sprinkled over the top. A fairly large excess of salt in proportion to the quantity of fish was used.

The changes which the fish held in pickle and in dry salt underwent at certain intervals of time are shown in Table 14.

As was to be expected, the water content of the fish decreased during the first 48 hours they remained in the salt and pickle, the loss being much greater in the case of those kept in dry salt. At the end of the 48-hour period the percentage of water lost by the eviscerated fish in pickle was practically the same as that lost by the uneviscerated fish. The uneviscerated fish in dry salt, however, showed at this period a slightly greater loss of water than did the eviscerated fish in dry salt. The water content of the fish kept in pickle and in dry salt for 96 hours increased from that shown for the 48-hour period, the increase being more marked in the case of the fish held in pickle.

There appears to be a greater loss of volatile nitrogen, as ammonia and amines, from the tissues of the fish when kept in pickle than when kept in dry salt. No change of a significant nature was found in the results obtained for the amino acid nitrogen or the acidity of the fat.

The fish used in the second experiment, brought to the laboratory during cool weather, were in good condition, having been but from 4 to 6 hours out of the water. They were oil size, packing on the average 6 fish to the can.

After a representative sample, designated as fresh fish in Table 15, had been taken from the entire portion, 500-gram lots were accurately weighed into beakers, and 350 cc of pickle reading 90° on the salimeter were added. At the expiration of the time intervals indicated in Table 15 the samples were removed and weighed, and the volume, specific gravity, and weight of the pickle determined.

Of the other fish, 500-gram portions were treated with 100 grams of salt. At the end of the stated periods the brine which had formed was poured off, and the whole mass of fish, rinsed free from adhering water and brine, was analyzed.

The results of the analyses of the fish appear in Table 15, and of those of the pickle in Table 16.

The loss in weight, 4.4 per cent of the original weight of the fish, which occurred during the first hour they were held in pickle, was almost doubled at the expiration of the 8-hour period. A gradual loss in both water and fat, corresponding to the length of time the fish remained in the pickle, occurred.

TABLE 15.—*Composition of fish held in pickle and in dry salt (1 to 18 hours).*

Condition of fish.	Weight of fish.		Loss in weight.		Chemical composition.							
					Samples as taken.					On water, fat, and salt free basis.		On water and fat free basis.
	Added to 350 cc of 90° pickle.	At end of time in pickle.			Water.	Fat.	Total nitrogen.	Total volatile nitrogen (ammonia and amines) per 100 grams.[3]	Salt.	Total nitrogen.	Total volatile nitrogen (ammonia and amines) per 100 grams.[3]	Salt.
Uneviscerated fish:	*Grms.*	*Grms.*	*Grms.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Mg.*	*Per cent.*	*Per cent.*	*Mg.*	*Per cent.*
Fresh	......	......	......	......	68.51	14.18	2.54	15.2	0.16	14.81	88.6	0.92
In pickle—												
1 hour	500	478	22	4.4	69.02	11.82	2.67	17.5	1.75	15.34	100.5	9.13
2 hours	500	466	34	6.8	67.83	11.76	2.73	14.0	2.12	14.93	76.5	10.39
4 hours	500	470	30	6.0	65.93	12.46	2.71	14.0	2.93	14.51	74.9	13.56
6 hours	500	470	30	6.0	64.28	13.67	2.77	17.4	3.38	14.84	93.2	15.33
8 hours	500	459	41	8.2	63.84	12.61	2.81	16.3	4.05	14.41	83.6	17.19
Same lot dry salted:[1]												
In salt—												
14 hours	500	427	73	14.6	55.82	14.92	3.02	15.2	8.54	14.58	73.4	29.19
18 hours	500	420	80	16.0	55.02	14.02	3.04	12.8	9.94	14.46	60.9	32.11
Eviscerated fish:												
Fresh	......	......	......	......	71.51	9.68	2.71	14.0	......	14.41	74.4	......
In pickle[2]—												
10 hours	212	195	17	8.0	69.59	10.31	2.61	13.4	......	10.83	57.7	......
12 hours	237	212	25	10.6	64.25	10.31	2.71	10.5	......	10.65	41.3	......
Same lot, uneviscerated:												
Fresh	......	......	......	......	70.79	9.81	2.63	11.6	......	13.56	59.8	......
In pickle—												
10 hours	317	290	27	8.5	62.92	12.50	2.80	16.3	......	11.39	66.3	......
12 hours	305	274	31	10.2	62.50	12.15	2.86	......	......	11.28	......	......

[1] In 100 grams of salt. [2] 200 cc of pickle, reading 90° on the salimeter, used. [3] By titration.

The results calculated to a water, fat, and salt free basis showed an actual loss of 0.40 per cent of nitrogen, corresponding to 2.50 per cent of protein during the 8 hours the fish were in pickle. The dry salted fish lost 14.6 per cent of their weight after remaining in salt for 14 hours and 16 per cent after being in salt for 18 hours.

Most of the loss in weight of fish held in dry salt may be ascribed to the abstraction of water from them. The water content of the fish held in dry salt is a little less than 1.0 per cent lower at the end of the 18-hour period than it was at the end of the 14-hour period. The total nitrogen in the fish for both periods in dry salt is less than the amount found in fresh fish, and is practically the same as that shown for fish held in pickle for 8 hours. The total volatile nitrogen content of the fish held in dry salt is much less than that of fish from the same lot which had been held in pickle.

The marked variation in the composition of the pickle in which the fish were held for the different periods compared with that of the fresh pickle (Table 16) shows in an even more striking manner the changes which the fish underwent.

TABLE 16.—*Composition of pickle in which fish were held (1 to 18 hours).*

Condition of pickle.[1]	Volume of pickle.		Specific gravity.	Weight.	Brine contained—			
	To which were added 500 grams fish.	Increased after alloted time to.			Total nitrogen.	Total volatile nitrogen (ammonia and amines).	Amino acid nitrogen.	Salt.
With uneviscerated fish:	*Cc.*	*Cc.*		*Grams.*	*Mg.*	*Mg.*	*Mg.*	*Per cent.*
Fresh			1.1729	410.5	(2)	0.0	4.9	22.75
After 1 hour	350	368	1.1487	422.5	94.41	4.1	16.9	18.98
After 2 hours	350	370	1.1400	421.8	144.39	5.7	22.9	18.06
After 4 hours	350	375	1.1306	423.9	(2)	6.3	26.7	16.86
After 6 hours	350	380	1.1280	428.6	262.73	8.0	31.5	16.36
After 8 hours	350	403	1.1212	451.8	360.36	13.5	46.5	15.47
With dry salted fish:[3]								
After 14 hours	(4)				189.97		53.0	
After 18 hours	(5)				242.75		63.0	
With eviscerated fish:								
Fresh	(6)		1.1841	236.8	1.5	0.0	3.2	23.31
After 10 hours	200	222	1.1365	252.3	244.2	7.5	46.3	17.56
After 12 hours	200	228	1.1227	255.9	291.8	6.9	42.9	14.95
With uneviscerated fish (same lot as last):								
After 10 hours	200	231	1.1200	258.7	254.1	10.7	67.9	14.89
After 12 hours	200	232	1.1200	259.8	290.0			14.89

[1] Pickle used with fish the analyses of which are given in Table 15.
[2] Lost.
[3] 100 grams of salt to 500 grams of fish.
[4] 125 cc brine collected made to volume of 200 cc.
[5] 130 cc brine collected made to volume of 200 cc.
[6] Volume to which first added.

The volume and weight of the pickle increased gradually and the specific gravity decreased during the time the fish remained in it. The amount of material extracted from the fish in the pickle, represented by the total nitrogen, ammonia and amines, and amino acid nitrogen, gradually increased, while the percentage of salt in the pickle gradually decreased with the length of time the fish remained in it. More nitrogenous material was extracted from the fish during the 18-hour period in salt than during the 14-hour period. The total nitrogen extracted from the fish held in salt was noticeably less than that removed during the 6 and 8 hours they remained in pickle. More of this nitrogen, in the form of amino acids, was extracted when the fish were kept in dry salt than when kept in pickle.

A supplementary experiment was made with a second lot of fish part of which were eviscerated and part of which were not. These fish, which contained about 5 per cent less fat than those used in the previous experiment, were kept in pickle for from 10 to 12 hours. Different weights of fish were added to 200 cc of pickle which read 90° on the salimeter.

The eviscerated fish and uneviscerated fish [1] showed practically the same percentage loss of weight at the end of the 10- and 12-hour periods in pickle. The loss at the end of 12 hours in both was greater by approximately 2 per cent than that at the end of the 10-hour period. A greater loss of total nitrogen and of ammonia and amine nitrogen occurred in the eviscerated than in the uneviscerated fish. More nitrogenous material was extracted from these fish than was lost by the lot used in the previous experiment when held in either pickle or dry salt. The weight and volume and specific gravity changes were slightly greater in the case of the pickle from uneviscerated fish, showing that a larger quantity of water was removed from uncut fish than from those in which the viscera had been removed. There was practically no difference in the total amount of nitrogen found in the pickle of the eviscerated and uneviscerated fish. The quantity of total volatile nitrogen, however, was slightly greater in the case of the uneviscerated fish.

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[1] These samples contained more fish to the quantity of pickle than the previous samples. The two sets of results are not, therefore, strictly comparable.

It is seen from these three sets of experiments that fish lose more water when dry salted than when held in strong pickle. The amount of nitrogenous material extracted in proportion to the amount of water removed is very much less in the case of fish held in dry salt than that extracted from fish held in pickle. More nitrogenous substances are extracted from eviscerated fish than from uneviscerated fish, while a greater amount of nitrogenous extractives is removed from fish relatively poor in fat than from fairly fat fish.

LARGE SCALE.

To secure experimental conditions which would approximate as nearly as possible those of actual practice and still keep the work under control, two additional experiments were conducted on the dry salting of fish.

The first one was made on fish from Grand Manan, which had been about 8 hours out of water. The weather was decidedly cool, so that they were in good condition. The largest fish were discarded, the experiment being conducted on 70 pounds, accurately weighed to one-half ounce, of one-quarter oil and three-quarter mustard size.

The salting, which was done in a small barrel provided with a hole in the bottom, through which the pickle could be drawn off at intervals, was at the rate of one sack to a hogshead, which is approximately 180 pounds of salt to 1,000 pounds of fish, or 13 pounds to 70 pounds of fish. The brine was drawn off after the first hour and the second hour, and then at 2-hour intervals. A sample of the fish designated as fresh was taken from the lot as it was being salted. After drawing off the brine at each time interval, a sample of fish was removed, weighed, washed free from adhering salt, the heads removed, and ground thoroughly. The brine collected after each interval of time was measured, weighed, and analyzed. The results of the analyses are given in Table 17.

A gradual loss of water occurred during the entire period the fish remained in the salt until at the end of 12 hours a reduction of 11.07 per cent in moisture is noted. This loss was accompanied by an apparent gain in fat of 2.43 per cent, which, however, on being calculated to a water free basis, becomes an actual loss of 3.10 per cent. On a moisture, fat, and salt free basis 4.06 per cent of nitrogenous material was abstracted from the fish by the action of the salt and brine. The ammonia and amine nitrogen content, which fluctuated markedly, showed a general tendency to decrease in accordance with the length of time the fish remained in salt.[1] In this particular lot of fish the maximum amount of salt was absorbed during the 8-hour period.

As soon as the fish are placed in salt the formation of brine begins, and the results of analysis of the brine show that appreciable quantities of nitrogenous extractive material passed into this brine formed from water removed from the fish. The maximum amount of nitrogenous material was abstracted during the 4- and 6-hour periods of the time in salt, although the greatest quantity of brine was collected at the end of the 6-hour period. The quantity of nitrogen in the brine increased from only 206.3 mg during the first hour to 1,865 mg at the end of the second hour and was then fairly constant. The largest amount of nitrogen was obtained in the next period or at the expiration of 4 hours, during which time a total of 1,992.5 mg of nitrogen passed into the brine. During the next 2-hour period, in which the largest amount of brine was formed, the amount of nitrogen abstracted by the brine was but a few milligrams less than that found in the previous period.

The nitrogenous material extracted during the 8-, 10-, and 12-hour periods diminished noticeably, though still fairly large. The amount of ammonia and amine nitrogen per 100 cc of brine increased noticeably from the first hour on. The largest amount was found at the expiration of the 6-hour period, when a total of 90.3 mg is shown, after which a gradual decline is indicated. The greatest amount of amino acid nitrogen obtained, 435.9 mg, was found in the brine for the 4-hour period. This corresponds to the period in which the largest amount of protein material was abstracted. The total quantity of nitrogen in the brine for the entire 12-hour period was extracted at the rate of 152.4 mg per pound of fish.

The figures in Table 18 showing the loss of weight and the percentage loss of the total amount of fish and salt are interesting.

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[1] The ammonia content of the fish in this experiment was high because the samples had begun to deteriorate before the determination could be completed, and may also have been influenced by irregularity in salting and sampling.

TABLE 17.—*Chemical changes in fish held in dry salt.*

Description.	Volume.	Weight.		Specific gravity.	Water.	Fat.	Total nitrogen (N).	Total protein (N× 6.25).	Total volatile nitrogen (ammonia and amines) per 100 grams or cc.	Salt (NaCl).	Water, fat, and salt free basis.			Salt (NaCl) (water, fat free basis).	Amino acid nitrogen per 100 cc.	Total nitrogen (N).	Total volatile nitrogen (ammonia and amines).	Amino acid nitrogen.
											Total nitrogen (N).	Total protein (N× 6.25).	Total volatile nitrogen (ammonia and amines) per 100 grams.					
EXPERIMENT 1.																		
Fish:	*Cc.*	*Grams.*	*Oz.*		*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*Mg.*	*P. ct.*	*Mg.*	*Mg.*	*Mg.*	*P. ct.*	*Mg.*	*Mg.*	*Mg.*	*Mg.*
Fresh					69.27	10.34	2.79	17.44		0.33	13.91	86.94		1.62				
Held in salt—																		
1 hour					66.46	11.91	2.76	17.25	21.0	1.52	13.72	85.78	104.4	7.03				
2 hours					66.98	11.72	2.90	18.13	16.3	2.84	15.71	98.21	88.2	13.35				
4 hours					63.91	12.02	2.92	18.25	17.5	3.20	13.99	87.45	83.8	13.30				
6 hours					62.67	11.62	3.05	19.06	15.2	3.69	15.01	93.80	74.8	14.35				
8 hours					63.62	10.02	3.19	19.94	18.6	4.14	14.36	89.74	83.7	15.70				
10 hours					60.68	12.22	3.14	19.63	14.0	4.01	13.60	85.02	60.6	14.79				
12 hours					58.20	12.77	3.26	20.38	21.0	4.45	13.26	82.88	85.4	15.33				
Brine:																		
Saturated salt solution (blank)							0.00		0.00						[2] 1.62	0.0	0.00	
After holding fish—																		
1 hour	[1] 150	181	16.4	1.2066			.114		4.20						30.75	206.3	10.50	76.9
2 hours	850	992	35.0	1.1671			.188		4.48						33.75	1,865.0	38.08	286.9
4 hours	985	1,179	41.6	1.1969			.169		6.16						44.25	1,992.5	60.67	435.9
6 hours	1,075	1,282	45.2	1.1926			.154		8.40						33.75	1,974.3	90.30	362.8
8 hours	820	981	34.6	1.1963			.159		6.16						38.50	1,559.8	50.51	315.7
10 hours	755	902	31.8	1.1947			.173								40.25	1,560.5		303.9
12 hours	725	872	30.7	1.2028			.173		6.64						27.75	1,508.6	46.69	201.2
20 hours	1,610	1,917	67.6	1.1907														

EXPERIMENT 2.																		
Fish:																		
Fresh	......	......	......	......	63.84	17.97	2.52	15.75	8.2	.47	14.22	88.88	46.3	2.58	......	......	......	......
Held in salt—																		
1 hour	......	......	......	......	63.06	16.81	2.59	16.19	9.3	1.35	13.79	86.21	49.5	6.71	......	......	......	......
2 hours	......	......	......	......	60.07	18.96	2.64	16.50	......	1.56	13.60	85.01	......	7.44	......	......	......	......
4 hours	......	......	......	......	59.98	18.67	2.65	16.56	14.0	2.32	13.93	87.02	73.6	10.86	......	......	......	......
6 hours	......	......	......	......	54.48	20.00	2.75	17.19	14.0	2.72	12.06	75.39	61.4	10.66	......	......	......	......
8 hours	......	......	......	......	54.89	19.45	2.81	17.56	11.6	2.97	12.38	77.39	51.1	11.57	......	......	......	......
10 hours	......	......	......	......	55.54	17.87	2.82	17.63	10.5	4.12	12.55	78.46	46.7	15.50	......	......	......	......
12 hours	......	......	......	......	52.74	19.49	2.82	17.63	5.8	4.53	12.13	75.86	24.9	16.31	......	......	......	......
Brine:																		
Saturated salt solution (blank)	......	......	......	......	......	......	0.00	......	......	......	......	......	......	......	1.62	......	......	......
After holding fish—																		
1 hour	[3] 370	442	15.6	1.1954	......	......	.168	......	3.22	......	......	......	......	......	44.38	742.6	11.91	164.2
2 hours	950	1,157	40.8	1.2179	......	......	.183	......	......	......	......	......	......	......	46.88	2,117.3	......	445.4
4 hours	1,780	2,138	75.4	1.2011	......	......	.194	......	2.38	......	......	......	......	......	58.13	4,147.7	42.36	1,034.7
6 hours	1,490	1,795	63.3	1.2040	......	......	[4] .193	......	1.82	......	......	......	......	......	66.88	3,464.4	27.12	996.5
8 hours	1,285	1,546	54.5	1.2031	......	......	.188	......	3.08	......	......	......	......	......	57.50	2,906.5	39.58	738.9
10 hours	1,180	1,409	49.3	1.1941	......	......	.198	......	4.34	......	......	......	......	......	53.13	2,789.8	51.21	626.9
12 hours	1,075	1,284	45.3	1.1944	......	......	.200	......	2.38	......	......	......	......	......	52.50	2,568.0	25.56	564.4
20 hours	2,730	3,273	115.5	1.1989	......	......	......	......	......	......	......	......	......	......	......	......	......	......

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[1] Volume made to 250 cc for analysis.
[2] Saturated solution of salt.
[3] Stopcock found open, and all except that collected in the last 30 minutes of the first hour lost.
[4] Average.

The weight of the fish and salt decreased uniformly during the first 12 hours, but from the 12-hour to the 20-hour period it was small in comparison with the loss which occurred when the brine formed was drawn off at 2-hour intervals. Obviously not as much brine is formed after this period, when it is allowed to remain surrounding the fish. The greatest loss in weight occurred between the 4- and 6-hour periods, when 2.82 pounds, or 3.72 per cent, of the weight of the material at the beginning of this period was removed in the form of brine. The total loss of weight at the expiration of the 12 hours that the fish remained in salt was 17.9 pounds, which, corrected for the total weight of the samples taken (4.3 pounds), leaves 13.6 pounds, or 16.39 per cent, as the actual loss of water, salt, and protein material from the original weight of fish and salt. The total loss for the 20-hour period amounted to 18.4 pounds, or 22.17 per cent, of the original weight. In this particular lot of fish nearly one-quarter of the weight of the original fish and salt was abstracted by brine during the 20 hours in "dry salt."

TABLE 18.—*Loss in weight of fish held in dry salt.*

Condition of fish.	Weight of fish and salt.[1]		Weight of sample.	Loss in weight.			
	Total.	From which loss was obtained.					
EXPERIMENT 1.	*Pounds.*	*Pounds.*	*Pounds.*	*Grams.*	*Ounces.*	*Pounds.*	*Per cent.*
Fresh	[2] 70 [3] 13						
Held in salt—							
1 hour	82.6	81.9	0.7	181	6.4	0.4	0.50
2 hours	79.7	79.1	.6	992	35.0	2.2	2.68
4 hours	76.5	75.9	.6	1,179	41.6	2.6	3.29
6 hours	73.0	72.4	.6	1,282	45.2	2.82	3.72
8 hours	70.2	69.6	.6	981	34.6	2.16	2.98
10 hours	67.6	67.0	.6	902	31.8	2.0	2.87
12 hours	65.1	64.5	.6	872	30.7	1.92	2.87
20 hours	60.3			1,917	67.6	4.23	6.56
EXPERIMENT 2.							
Fresh	[2] 124 [3] 23						
Held in salt—							
1 hour	146.0	145.1	.9	442	15.6	0.98	.70
2 hours	142.5	141.6	.9	1,157	40.8	2.6	1.79
4 hours	136.9	136.0	.9	2,138	75.4	4.7	3.32
6 hours	132.0	131.9	.9	1,795	63.3	4.0	2.94
8 hours	128.5	127.6	.9	1,546	54.5	3.4	2.58
10 hours	124.5	123.7	.8	1,409	49.3	3.1	2.43
12 hours	120.9	120.0	.9	1,284	45.3	2.8	2.26
20 hours	112.8			3,273	115.5	7.2	6.00

[1] The first column gives the weight of fish and salt at the expiration of the different intervals of time at which the brine was drawn off. The second column shows the weight of fish and salt from which the brine for the succeeding interval of time was obtained. That is, the figures in the first column are corrected for the weight of the sample taken, forming the figures from which the true percentage loss for each interval was obtained.

[2] Fish.

[3] Salt.

The total volume of brine collected during the 20 hours the fish were in salt amounted to 6,970 cc, which, as a saturated salt solution, would contain 2,509 grams, or 5.5 pounds, of salt. Subtracting this amount of salt from the total actual loss during the 20-hour period gives 12.9 pounds, or 18.4 per cent, of water and protein material removed from the original quantity of fish. The same calculation applied to the results obtained for the 12-hour period indicates that 9.3 pounds, or 13.3 per cent, of water and protein material was extracted from the fish during this time.

The second experiment of this series was run on fish which had been but 3 hours out of the water, being, therefore, somewhat fresher than those used in the first experiment. They were of uniform size, about 7 inches long, and were much fatter than those of the previous lot. One hundred and twenty-four pounds of fish were treated in the same manner as the others (p. 40), using 23 pounds of salt. The results of analysis are recorded under "Experiment 2" in Table 17.

During the 12 hours they remained in salt these fish lost the same percentage of water as those in Experiment 1. A comparison of results for the two experiments shows that the fatter fish do not absorb salt quite as rapidly as the thinner ones. A more gradual absorption of salt up to, and including, the 8-hour period and a more marked increase during the 10- and 12-hour periods occurred in the fish used for Experiment 2. The percentage amount absorbed during the 12 hours, however, was practically the same for both lots of fish. The greatest quantity of ammonia and amines was found in the fish at the end of the 4-hour period.

The largest amount of brine was formed during the 2- to 4-hour interval. A decrease in the rate of formation of brine occurred when the brine was allowed to accumulate. The specific gravity of the brine was highest at the end of the 2-hour period. The greatest quantity of nitrogenous material extracted, represented by total nitrogen, was found at the end of the 4-hour period. The quantity of amino acid nitrogen was also correspondingly high for this period. In Experiment 1 the highest amount of protein material was extracted during the same interval of time, but the largest volume of brine was obtained at the end of the 6-hour period. The greatest quantity of ammonia and amines, as nitrogen, in the brine was found during the 10-hour period.

With the exception of the specific gravity of the brine and the results for ammonia and amines, the quantity of the materials determined declined gradually from the fourth period, when the maximum was reached, to the end of the 12-hour period. For the entire 12-hour period the total quantity of nitrogen in the brine was extracted at the rate of 151.1 mg. per pound of fish. None of the extractive materials was determined in the brine collected at the end of the 20-hour period.

During the first hour (Table 18) nearly 1 pound of material, or 0.7 per cent of the total weight of fish and salt at the beginning of the experiment, was lost. The greatest loss occurred at the end of the 4-hour period. After being "dry salted" for 20 hours, the total loss of material, water, salt, and protein substances amounted to 28 pounds, or 19.05 per cent of the weight of the fish and salt at the beginning of the experiment. This is 3.12 per cent less than that found in Experiment 1. The volume of the brine collected during the 20 hours amounted to 10,860 cc, which, as a saturated salt solution, would dissolve 3,910 grams, or 8.6 pounds of salt. This leaves 19.4 pounds as the actual loss of water and nitrogenous material removed from the fish during the 20 hours in salt, and is 15.65 per cent of the total weight of fish employed at the beginning of the experiment. This is 2.75 per cent less than that abstracted in Experiment 1 for the same period of time, showing that the fatter fish lose less extractive material while in salt.

Practically one-quarter and one-fifth, respectively, of the original weight of fish and salt was lost in 20 hours, the smaller loss occurring in the case of the fatter fish. An appreciable amount of nitrogenous substances was extracted from the fish during the time they remained in salt, although, as shown by the figures in Table 15, not as much as would have been removed had the fish remained in pickle for corresponding periods. This is due to the fact that a number of protein substances are rendered insoluble by salt and very strong salt solutions. As the solution grows weaker, or if very weak pickle is used, a larger proportion of these protein substances are dissolved. These substances give fresh fish the characteristics which distinguish them from salt fish. The maximum quantity of the nitrogenous material was extracted at the end of the first 4 and 6 hours, a marked increase being shown at these periods over the 2-hour period when the fish were salted at the rate of one sack per hogshead.

The results of these experiments indicate that 2 hours or less is the proper period of time for pickling or dry salting the fish, when the loss of the minimum quantity of extractive material is considered. The time allowed in the older method when the fish were pickled in the pickling sheds, usually 2 hours, permits the conservation of the maximum quantity of those extractive substances which are characteristic of fresh fish.

Effect of Various Steps in Canning Process on Salt Content of Sardines.

A number of analyses were made to determine the variation of the salt content of the fish at different stages of the canning process under actual commercial practice. The results are given in Table 19.

TABLE 19.—*Variation in salt content of fish at various stages of the canning process.*

Condition of fish.	Salting and pickling period.		Chemical composition.				
	Dry salted in boat.	In pickle in factory.	On original samples.				On water and fat free basis.
			Water.	Fat.	Salt.	Ash.	Salt.
Lot 1 (oil size):	*Hours.*	*Hours.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*
From boat	3		70.30	10.48	0.65		3.38
From pickle	3	3	72.96	7.24	1.50		7.57
After steaming	3	3	69.33	7.31	1.25		5.35
From drier (18 hours)	3	3	63.52	8.33	1.77		6.29
Lot 2 (oil size):[1]							
From boat	24		59.04	9.37	3.08		7.40
After steaming and drying	24		54.12	18.66	3.13	5.23	11.49
Packed in can, sealed, but not processed	24		43.54	31.74	3.52		14.23
Packed in can, sealed, and processed	24		48.23	27.92	2.70		11.32
Lot 3 (oil size):							
From flakes before steaming	8		69.63	7.15	2.22		9.56
From flakes after steaming and drying	8		61.40	9.30	2.11		7.20
Packed in oil and processed	8		50.36	24.60	2.03		8.11
Lot 4 (oil size):							
From boat	2		68.62	9.40	.75	2.92	3.41
From pickle	2	1	60.33	15.11	1.93	3.08	7.86
After steaming and drying	2	1	60.77	14.32	2.04	3.45	8.19
Packed in oil and processed	2	1	54.02	16.81	1.61	3.16	5.52
Lot 5 (mustard size):							
From boat	24		59.59	13.16	1.53		5.61
After steaming and drying	24		58.58	17.12	1.96	3.71	8.06
Packed in mustard sauce, sealed, and processed	24		67.14	16.14	2.35	3.87	14.05

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[1] Salted at the rate of 1 sack per hogshead.

It is seen that the salt content is most seriously affected by the steaming process, which readily removes the salt, especially when it is present in large amounts. Further tests were therefore made to determine how much salt is lost by steaming fish under certain conditions. The results which appear in Table 20 are self-explanatory.

TABLE 20.—*Effect of steaming on salt content of the fish.*

Condition of fish.	Water.	Fat.	Salt.	Salt (water and fat freebasis).	Loss.
Lot 1:	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
Out of pickle	66.61	5.93	6.66	24.25	
Off flaking machine	64.08	6.13	6.50	21.82	2.43
Steamed 10 minutes	61.80	6.78	5.78	18.40	3.42
Steamed 15 minutes	62.71	7.07	5.57	18.43	
Lot 2:					
Out of pickle	66.43	11.53	2.24	10.02	
Flaked and steamed 12 minutes	65.28	10.74	1.97	8.21	1.81

EFFECT OF CUTTING AND EVISCERATING ON LENGTH OF TIME IN PICKLE.

Two large samples of eviscerated and uneviscerated fresh fish were held for varying periods of time in pickle made up to read 90° on the salimeter and containing a slight excess of salt in a solid state.

The amount of pickle used, about 1½ buckets in each case, was relatively somewhat more than would be employed in actual practice. At the end of each of the periods indicated in Table 21 samples of the fish were flaked, steamed for 10 minutes, dried, cooled, packed, oiled, and processed for 2 hours. The salt content of the fish subjected to this treatment is shown in Table 21.

TABLE 21.—*Salt content before and after packing of cut and uncut fish held for varying periods in pickle.*

Condition of fish.	Water.	Fat.		Salt.			
		Samples as taken.	Water free basis.	Samples as taken.	Water free basis.	Increase.	Gain or loss after steaming, packing, and oiling.
	Per cent.	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
Cut fish taken from pickle:							
Unsalted (fresh)	71.47	7.84	27.47	0.33	1.59	....	....
In pickle—							
30 minutes	67.24	10.34	....	2.16	9.64	8.05	....
1 hour	67.90	8.85	....	3.27	14.07	4.43	....
2 hours	67.31	8.65	....	4.25	17.69	3.62	....
3 hours	65.41	9.81	....	5.47	22.07	4.38	....
4 hours	64.55	9.48	26.74	5.82	22.41	.34	....
Uncut fish taken from pickle:							
Unsalted (fresh)	66.12	13.61	40.17	.30	1.48	....	....
In pickle—							
30 minutes	66.54	12.15	....	1.35	6.34	4.86	....
1 hour	66.35	12.46	....	1.68	7.93	1.59	....
2 hours	65.71	10.24	....	2.85	11.85	3.92	....
3 hours	60.58	14.77	....	3.19	12.94	1.09	....
4 hours	59.36	14.25	35.06	3.77	14.28	1.34	....
Cut fish after steaming, packing, and processing:							
Unsalted (fresh)	48.42	28.38	....	.42	1.81	....	+0.22
In pickle—							
30 minutes	48.11	29.09	....	1.92	8.41	6.60	−1.23
1 hour	46.87	29.49	....	2.27	9.60	1.19	−4.47
2 hours	44.40	30.60	....	2.87	11.47	1.87	−6.22
3 hours	35.45	35.25	....	3.98	13.58	2.11	−8.49
4 hours	42.73	32.84	....	4.00	16.35	2.77	−6.06
Uncut fish after steaming, packing, and processing:							
Unsalted (fresh)	51.61	25.47	....	.43	1.89	....	+ .41
In pickle—							
30 minutes	51.98	24.88	....	1.81	5.67	3.78	− .67
1 hour	46.53	30.95	....	1.79	7.95	2.28	+ .02
2 hours	40.69	32.38	....	2.45	9.13	1.18	−2.72
3 hours	35.12	36.17	....	3.22	11.22	2.09	−1.72
4 hours	44.83	31.27	....	3.21	13.43	2.21	− .85

A comparison of the actual amounts of salt absorbed at the expiration of each period shows that the cut, or eviscerated, fish take it up much more readily than the uncut fish. At the end of 30 minutes the cut fish had absorbed more salt than the uncut fish at the expiration of one hour, and at the end of one hour in pickle they had absorbed practically the same amount of salt as was found in the uneviscerated fish after 4 hours in pickle. At the close of the 4-hour period in pickle, the eviscerated fish had taken up about 57 per cent more salt than the uneviscerated fish for the same period of time. At the end of the experiment after 4 hours, the pickle of both the cut and uncut fish read 85° on the salimeter. One-fourth of the time necessary for the uneviscerated fish to remain in strong pickle (90°) is sufficient for the eviscerated fish to acquire an equivalent salt content.

The effect of steaming on the salt content of the sardines packed from these two lots of fish shows the same relative differences at the various intervals of time as existed when the raw fish were taken from the pickle. The loss of salt by steaming was greater in the cut and eviscerated fish than in the uncut fish. The salt content of the packed goods prepared from fish held in pickle 30 minutes was much higher in the case of cut fish than that from uncut fish which had been in pickle one hour. The degree to which steaming removes the excessive amount of salt is well shown in the case of cut fish which had been in pickle for 2, 3, and 4 hours. Before steaming these fish contained 17.69, 22.07, and 22.41 per cent of salt, respectively. After steaming and packing they contained 11.47, 13.58 and 16.35 per cent, a loss of 6.22, 8.49 and 6.06 per cent. The pack from the uncut fish, which had been in pickle 4 hours, contained 13.43 per cent of salt, a loss of only 0.85 per cent from the amount found in the raw fish. These results show the extent to which steaming removes the salt from the fish, particularly where it is present in large amounts.

A comparison of the salt content of eviscerated with that of uneviscerated fish, at different lengths of time in pickle, points unmistakably to cutting and eviscerating as the means for obtaining the proper salt content of fish in the minimum period of time. It also follows, therefore, that cutting and eviscerating permit the proper pickling of the fish with the least loss of extractive material.

Fish that are to be fried in oil when cut and eviscerated require much less time in pickle than fish which are to be steam cooked. From 10 to 15 minutes in a 90° pickle should be sufficient for eviscerated fish which are to be fried in oil.

During the course of this experiment it was noticed that, while the bellies of the uncut fish broke out to some extent during the time they were held in pickle, the cut fish showed no signs of being belly broken.

Distribution of Salt in Sardines.

The distribution of salt in the skin and meat of the uncut fish and the loss of salt from the skin after steaming were determined. One set of samples was prepared by removing the skin from a number of fish which had been in dry salt for seven hours. Another set was prepared from the same lot of fish which had been steamed for 10 minutes. The results of the analyses of these two sets of samples are shown in Table 22.

TABLE 22.—*Distribution of salt in uncut fish.*

Contained in—	Water.	Fat.	Salt.	Salt (water and fat free basis).	Loss.
	Per cent.	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
Skin	63.70	14.62	4.05	18.59	
Flesh	70.76	3.56	1.79	6.97	
Skin:					
Before steaming	56.03	21.98	4.26	19.37	
After steaming 10 minutes	50.41	28.09	2.15	10.00	9.37

The skin contained four times the amount of fat or oil, and nearly two and one-half times the quantity of salt found in the flesh. The fact that one-half the amount of salt present in the skin was lost during the steaming process explains the removal of the large percentage of the salt contained in the fish shown in Table 19.

Percentage of Salt in Sardines.

To obtain an idea of the length of time necessary for fish to remain in pickle to attain the proper salt flavor, a number of samples from the foregoing experiments (Table 21) were submitted to an impartial jury with no knowledge of the way the products had been prepared. Of the uneviscerated fish, the pack composed of fish which had been three hours in pickle was judged the best, while in the case of the eviscerated fish, the majority favored the packs which had been in pickle for from one to two hours.

Of the packs which were regarded favorably, the uneviscerated fish contained 3.22 per cent of salt, and the eviscerated fish 2.27 and 2.87 per cent. This discrepancy may be explained by the fact that the viscera of uncut fish which have been held in pickle or salt contain a higher percentage of salt than does the flesh which was the part tested.

While the question of the best flavor is a matter of individual taste for which no hard and fast rule may be made, an average of 3 per cent of salt may be considered the most satisfactory. At all events, an amount varying from 2.5 to 3.5 per cent in the finished product would prove satisfactory to the majority of people. It would seem wise to undersalt rather than oversalt the fish.

FLAKING THE FISH.

The purpose of flaking is to distribute the fish evenly on flakes, or wire-meshed rectangular frames, so that the drying medium can reach them all uniformly when the flakes are taken into the drying room. This purpose seemed to have been entirely forgotten in the many instances where the fish were found piled high up on the flakes, that thereby became containers of fish rather than drying racks. Figure 1, Plate XIV, shows a flake where the fish are entirely too thick, although it does not represent the maximum number of fish found upon one flake during the course of the investigation. Sometimes fish which have been flaked too thickly become glued together during the drying process (Pl. XIV, fig. 2), making it necessary to tear them apart before placing them in the cans, much to the detriment of the pack. Too thick flaking also causes uneven drying. It has been demonstrated that thin flaking of the fish results in a better degree of drying in a shorter period, facilitates packing, eliminates waste due to marred and broken fish, and produces a larger yield and a better looking can of goods.

The number of fish of various sizes that can be distributed to best advantage on the flake is shown in Table 23.

TABLE 23.—*Number of fish of various sizes per flake* (*hand flaked*).

Size of flakes.		Number of fish.				
Over all.	Internal.	4-inch.	5-inch.	6-inch.	7-inch.	8-inch.
Inches.	*Inches.*					
22 by 36	19 by 33	106	87	53	49	48
30 by 30	27 by 27	131	104	84	52	48

Several canneries packing the higher grades of sardines flake the fish by hand, thereby securing a very even distribution and eliminating the losses from mechanical injury. Where machines are used for this purpose, the utmost care should be given to their operation to avoid a thick and uneven flaking of the fish.

DRYING THE FISH.

Drying is a very important step in the canning of sardines, particularly in the case of those which are steam cooked. Packers who fry the fish in oil realize the necessity of frying only fish which have been properly dried in order to prevent spattering and breaking when the fish are first placed in the fryer. Fish after frying in oil do not contain an excessive amount of water, one point of superiority of fried sardines over poorly dried steam cooked sardines. Fried fish contain a fairly uniform quantity of water, ranging from 60 to 64 per cent, which should be the limit for the degree of dryness to which steamed fish are brought before packing.

In the tunnel type of driers where the removal of the excess water is accomplished by drawing a current of warm air over racks of the flaked fish, a number of factors make a rigid control of drying quite difficult and at times impossible. These factors (some of which can be controlled) are the humidity of the air, the volume and temperature of the air passing through the drier, the size of the fish, the amount of water they contain, the surface exposure, and the time allowed for drying. In many instances more attention given to those controllable conditions responsible for the variations in the degree of dryness to which steamed fish are brought before being packed would insure a higher quality pack than when they are disregarded.

In the examination of a number of cans of inferior sardines during the early part of this investigation it was discovered that the conditions found could be attributed, in many cases, to insufficient drying of the fish.

The influence of some of the factors responsible for variations in the water content of the packed fish is shown in the results collected and experiments made on drying under various conditions during the course of this investigation.

EFFECT OF STEAMING AND DRYING ON COMPOSITION OF SARDINES.

Five lots of fish were steamed and dried under varying conditions, with the results shown in Table 24.

TABLE 24.—*Effect of steaming and drying on moisture and fat content of sardines.*

Stage of canning.	Water.	Fat.	Difference.	Actual loss of water.
Lot 1 (large fish):	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
From flakes	59.90	17.61	...	...
From steam box (steamed 15 minutes)	61.94	...	[1] 2.04	...
From drier (dried $1\frac{1}{2}$ hours)	59.10	17.00	.80	1.96
Lot 2 (three-quarter mustards):				
From steam box	62.31	15.62	...	...
From drier	61.30	14.36	1.01	2.61
Lot 2 (one-quarter oils):				
From steam box	70.12	6.99	...	...
From drier	60.94	...	9.18	23.50
Lot 3:				
From boat	66.20	...	...	...
From flaking machine	64.01	12.81	2.19	6.08
Steamed 15 minutes and dried 15 minutes (kiln drier)	59.70	...	6.50	16.13
Lot 4:				
From pickle	70.31	...	...	...
Steamed	68.31	...	2.00	6.31
Dried	59.94	...	8.37	25.89
Lot 5:				
From pickle (in pickle 12 hours)	60.08	8.49	...	...
Steamed and dried	59.31	12.65	.77	1.89

[1] Possibly due to irregularity of sampling.

Since large fish require a longer drying period than small fish, the packer should grade his fish by size before sending them to the drying room.

EFFECT OF VARIOUS CONDITIONS OF DRYING ON SARDINES.

Experiments were conducted in certain canneries to ascertain the amount of water driven from fish under various conditions of drying and to determine the effect on the quality of the sardines of packing fish containing various quantities of water. The analytical results given in Table 25 show the water content and percentage loss of water under different conditions and periods of drying.

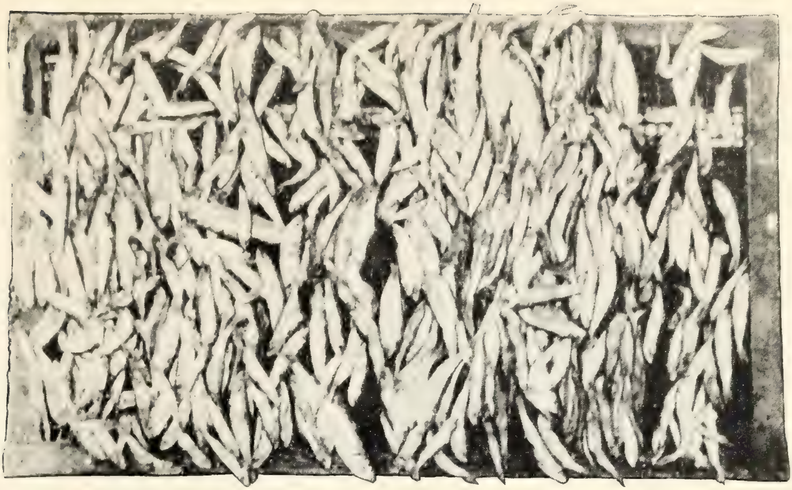

FIG. 1.—FISH FAR TOO HEAVILY FLAKED.

The fish can not be properly dried when so thick, and when roughly and carelessly pulled apart they are greatly marred and damaged as they are packed.

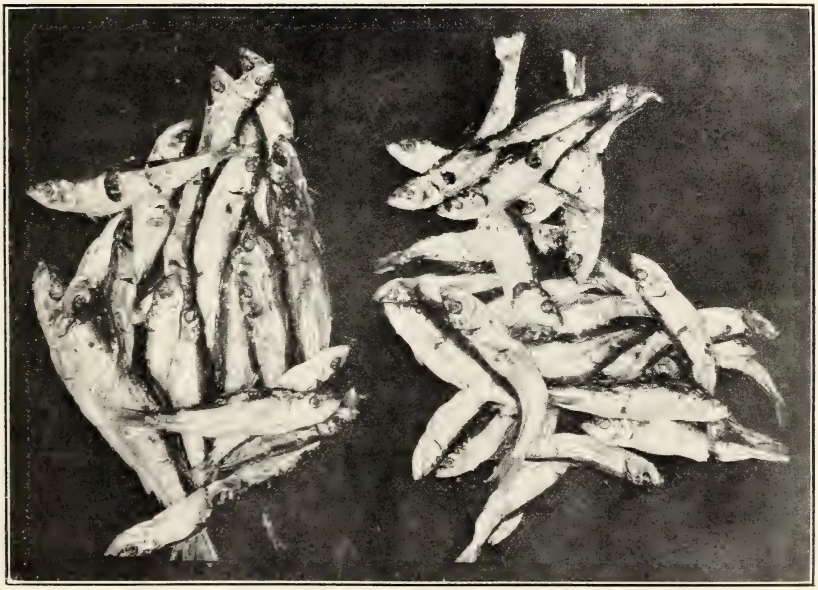

FIG. 2.—FISH SO THICKLY FLAKED THAT THEY BECOME GLUED TOGETHER IN DRYING.

Entire sections of fish of this size and larger could be removed from flake. Note transverse cracks on fish caused by excessive salting. (Castine fish.)

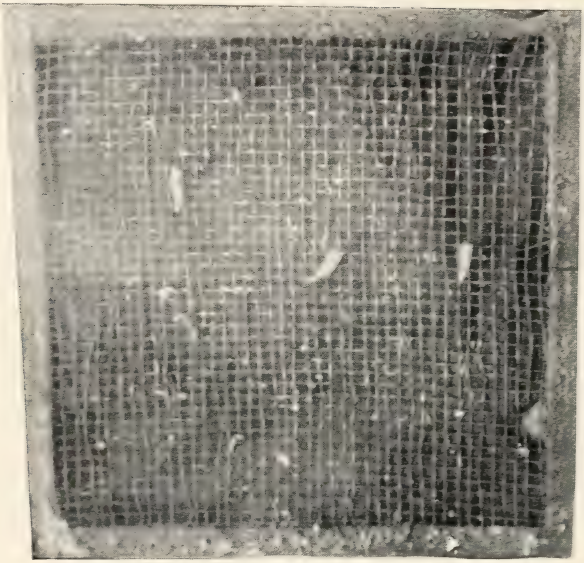

FIG. 1.—A DIRTY FLAKE.

Note the remains of fish and débris adhering to the wires and edges.

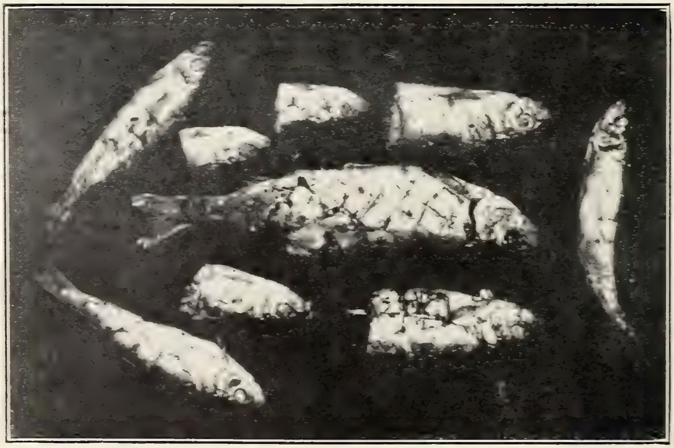

FIG. 2.—FISH MARRED BY MARKS FROM DIRTY FLAKES.

Note also the waste caused by cutting back fish of large size.

TABLE 25.—*Effect of various conditions of drying on water content of fish.*

Condition of fish.	Water content.	Difference.	Actual loss of water.
Lot 1 (three-quarter mustards):	*Per cent.*	*Per cent.*	*Per cent.*
From steam box	63.65		
Dried 2 hours at 100° F.	59.98	3.67	9.20
Dried 7 hours, left over night, and dried 1½ hours the following morning.	54.20	5.78	20.63
Lot 2 (three-quarter mustards):			
Raw fish (after salting)	63.88		
From steam box	63.86		
Dried 15 minutes, 1 revolution of wheel, coal fire, left at room temperature for 40 hours	55.70	8.18	18.47
Lot 3 (one-quarter oils):[1]			
Raw fish (after salting)	65.40		
From steam box, not dried	64.70	.70	1.98
Dried 20 minutes	62.33	2.37	8.15
Dried 40 minutes	64.28	1.95	3.14
Dried 1 hour	61.12	1.21	11.01
Dried 1 hour and 20 minutes	62.67	1.55	7.31
Dried 1 hour and 40 minutes	62.53	.14	7.43
Dried 2 hours	60.63	1.90	12.17
Lot 4 (one-quarter oils):[2]			
Raw (after salting)	70.38		
From steam box (steamed 15 minutes)	67.64	2.74	8.47
Dried 20 minutes[3]	64.75	2.89	15.97
Dried 40 minutes	61.18	3.57	23.70
Dried 1 hour	61.18	0.00	23.70
Dried 1 hour and 20 minutes	62.26	1.08	21.52
Dried 1 hour and 40 minutes	58.40	3.86	28.80
Dried 2 hours	58.05	.35	29.32

[1] Rain fell during the entire day, making the conditions most unfavorable for drying.

[2] Experiment conducted on a bright, clear, cool day, ideal for drying.

[3] Usual air (tunnel) dryer, run with a very large volume of air a little hotter than that usually found, was used.

The marked difference in the rate of drying of lot 3 and that of lot 4 is due to the presence in the air of moisture during the entire day on which the experiment with lot 3 was conducted. The effect of such unfavorable drying conditions is well shown in the small variations in the water content of the fish at different intervals of drying, an actual loss of only 12.17 per cent of water occurring during the 2 hours the fish remained in the drier.

The experiment on lot 4, consisting of fish from Castine, strongly salted and of a size packing 14 to 18 fish to the can, was conducted on a bright, clear, cool day, ideal for drying. The air (tunnel) drier was run with a large volume of air, a little hotter than is customary, the temperature in front of the steam coils ranging from 110° to 115° F. The total loss of water from these fish amounted to 29.32 per cent for the two hours they were in the drier. Under the conditions prevailing drying for a period of from 20 to 30 minutes would have been sufficient for this particular lot of fish. The fish being packed at the cannery from the same lot, however, were being dried from 40 to 45 minutes.

The physical appearance of the various packs at the different drying intervals was as follows:

Lot 1.—The mustard sauce in the cans packed with fish taken directly from the steam box was darker and somewhat thinner than the original sauce, and contained small particles of broken flesh. The flesh of the fish was dark and soft. The mustard sauce in the pack dried for 2 hours was brighter, and contained no particles of fish. The flesh of this fish was white and firm. The mustard sauce surrounding the fish which had been dried 7 hours, allowed to stand overnight, and then dried 1½ hours was bright and of about the same consistency as when put in the can, and showed no particles of fish. The flesh of this fish was very firm, although not as white as that of the fish dried for 2 hours. The contents of the cans of this last pack when opened had the best appearance of all four lots. The pack dried 2 hours differed very little in taste from that which was dried the longer time. The proper quantity of water to be driven from this particular lot of fish to be packed as mustards would seem to be 20.63 per cent.

Lot 2.—On opening the cans of raw fish from this pack a few days after they had been put up, it was found that the mustard sauce, which was of a different brand than that used in the case of lot 1, was quite thin, but retained its yellow color. The fish were soft, and had a characteristic fresh fish taste. The mustard sauce of the fish packed as they came from the steam box was of a good color and consistency, and the fish were fairly firm. The fish which had been dried and baked were, if anything, firmer than those from the steam box, but otherwise the same. The fish which had been dried, baked, and allowed to stand for an excessive length of time at room temperature were firm and hard. The mustard sauce was thick and pasty, as all the water it originally contained had been absorbed by the fish, which, however, remained hard and dry. The fish that had been packed raw differed very markedly in appearance from those packed after an excessive period of drying. In this experiment the cans with the best appearance and quality were those from the pack that had been dried for 15 minutes.

Lot 3.—The steamed fish packed without drying were soft, and the cans contained a great deal of water. Fish dried 20 minutes were much firmer, and the oil surrounding them appeared to be in good condition. The fish dried for 2 hours were the firmest of the lot, and the oil around them was the best in appearance and flavor. The physical examination of this pack was made before the determinations for water were completed. All who participated in the examination wondered at the apparent lack of improvement in the packs which were dried for the customary periods of time. The reason for this was evident when the moisture content was known (Table 25).

Lot 4.—When cans from this pack were opened and compared, it was the consensus of opinion that for both the oils and the mustards, drying for 20 minutes gave a product of very good appearance and flavor. There was not much difference between the packs after drying for 20 and for 40 minutes. It was apparent that, with this particular lot of fish, drying for a period of from 20 to 30 minutes under the conditions prevailing would have been sufficient. The fish packed after longer periods of drying were too hard, and did not make a good appearing or tasting can of sardines.

The results of these experiments show the wide divergence in the quality of sardines packed from fish containing varying amounts of water. It is true that at certain times, when the intervals of drying are short or conditions for drying the best, no very great difference in the packed goods is noticeable. The drying period should be as short as is consistent with securing the proper degree of dryness for the product.

Work still remains to be done in establishing simple tests to determine when the proper degree of dryness has been reached. It may be suggested here that the weight of a number of fish of uniform size, taken from the flakes as they enter the drier, be accurately determined. When the weight of an equal number of fish of the same size after drying is 15 per cent less than the weight of the raw fish, the proper state of dryness within the established limits will have been reached.

Oil sardines packed from fish insufficiently dried have a distinctly poor appearance. They are soft, and can not be taken readily in a whole condition from the can, while the oil surrounding them often looks milky and usually contains large drops of water. The taste is also decidedly bad, often soapy, a condition probably caused by the saponification of a small part of the oil during the sterilizing process in the presence of the excessive amount of water in the can. If dried too much, the fish become dry, hard, and brittle, and the flavor of the oil is strongly predominant. Oil sardines prepared from overdried, hard fish lack the characteristic fish flavor.

Variations in Water Content of Dried Fish Taken the Same Day from Different Canneries.

A series of samples were taken from several canneries at practically the same time of day, to determine how efficiently the fish were being dried, and to ascertain the variations in the degree of drying in the different canneries. Three of the canneries from which samples were taken were equipped with tunnel driers, one with the Ferris wheel oven type, and one with the old-style kiln drier. The time of drying was 60 minutes, 14 minutes, and 3 minutes, respectively, for the three types of driers.

The description of the samples, the kinds of driers, the conditions surrounding drying, and the results of this test are given in Table 26.

TABLE 26.—*Variations in water content of dried fish taken the same day from several canneries.*

Fish from [1]—	Date taken.	Weather conditions.	Cannery A, equipped with kiln drier (Ferris wheel, oven type).			Cannery B, equipped with tunnel drier (current of warm air).			Cannery C, equipped with kiln drier (oven type).			Cannery D, equipped with tunnel drier (current of warm air).			Cannery E, equipped with tunnel drier (current of warm air).		
			Time in drier.	Water.	Actual loss of water.	Time in drier.	Water.	Actual loss of water.	Time in drier.	Water.	Actual loss of water.	Time in drier.	Water.	Actual loss of water.	Time in drier.	Water.	Actual loss of water.
			Mins.	*Per ct.*	*Per ct.*	*Mins.*	*Per ct.*	*Per ct.*	*Mins.*	*Per ct.*	*Per ct.*	*Mins.*	*Per ct.*	*Per ct.*	*Mins.*	*Per ct.*	*Per ct.*
	1914.																
Steam box [2]	Oct. 2	Clear		70.51			65.42			70.61			68.93			68.37	
Drier	do	do	14	65.93	13.44												
Packing tables [3]	do	do		63.02	20.26	60	59.25	15.14	3	66.77	11.56	60	63.47	14.95	60	68.36	0.03
Steam box	Oct. 3	do	14	69.78			65.34			65.14			69.43			67.14	
Drier	do	do	14	66.83	8.89	60	[2] 58.36	[2] 16.76	3	[2] 60.09	[2] 12.65	60 780	[2] 62.95 57.47	[2] 17.49 28.12	60	[2] 66.76	1.15
Steam box	Oct. 6	do		70.62			70.01									68.21	
Drier	do	do	14	69.60	3.35												
Packing tables [3]	do	do	14	66.59	12.06	60	55.69	32.32							60	66.92	3.90
Steam box	Oct. 9	Raining.		69.01			67.79			69.23		60	69.19			68.47	
Packing tables [3]	do	do	14	65.35	10.57	60	67.64	.46	3	66.25	8.83		65.38	11.01	60	64.91	10.15

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[1] All fish 5 inches long.

[2] From packing table.

[3] After 2 hours in packing room.

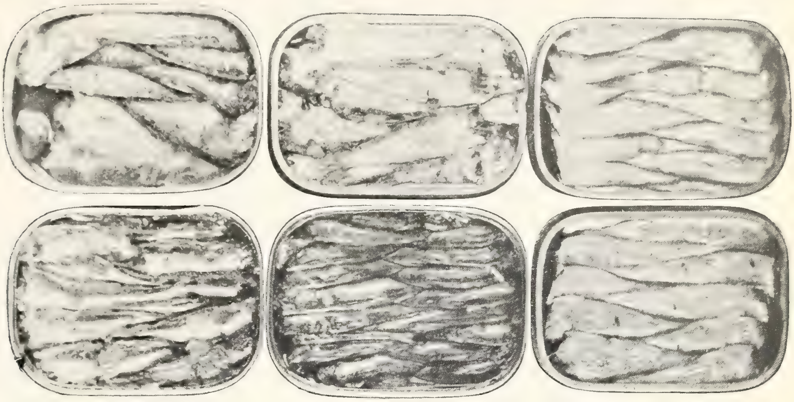

FIG. 1.—TWO WELL PACKED CANS, BRIGHTS UP, CONTRASTED WITH POORLY PACKED CANS, BACKS UP, AND TWO POORLY PACKED CANS, BRIGHTS UP.

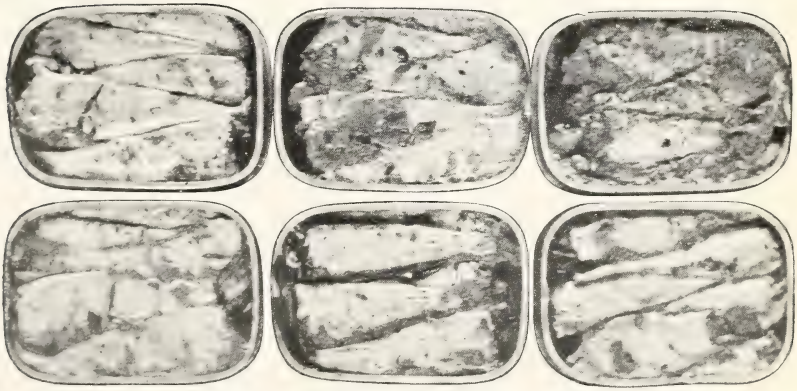

FIG. 2.—CANS OF SARDINES FAIRLY WELL PACKED, BUT MARRED BY ROUGH HANDLING.

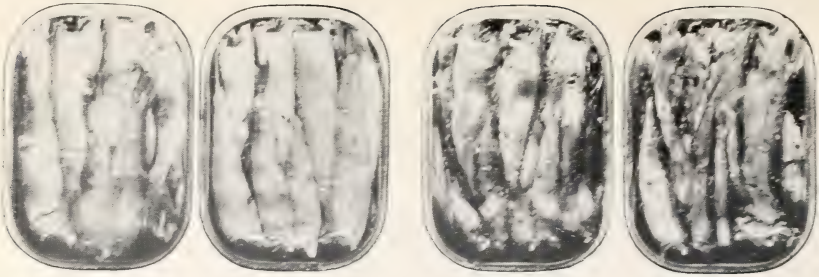

Fig. 1.—An Example of Good Packing Contrasted with Poor Packing.

Cans taken from packing table before being oiled. Same lot of fish, taken from the same weir on the same day, but packed by different concerns.

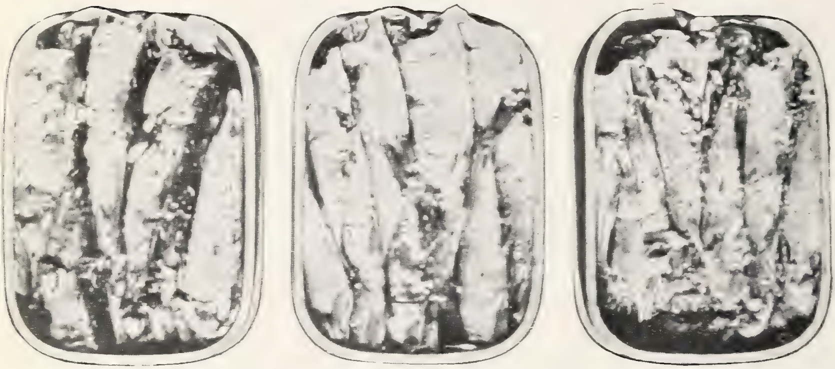

Fig. 2.—Sardines from the Same Lot as Those Well Packed in Fig. 1, Taken from the Shipping Room.

Note the disarrangement of the fish, due to rough handling after being processed. The mussy appearance is due to the presence of particles from the gills of snipped fish and material from the intestines.

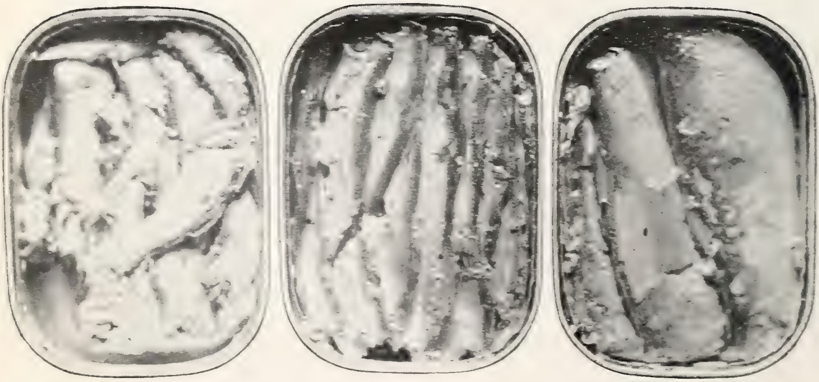

Fig. 3.—Sardines from the Same Lot as Those Poorly Packed in Fig. 1, Taken at Random from Shipment Ready for Market.

Unattractive appearance is due to slack packing and rough handling. Note the 3-fish can which shows the absence of standardization of the pack.

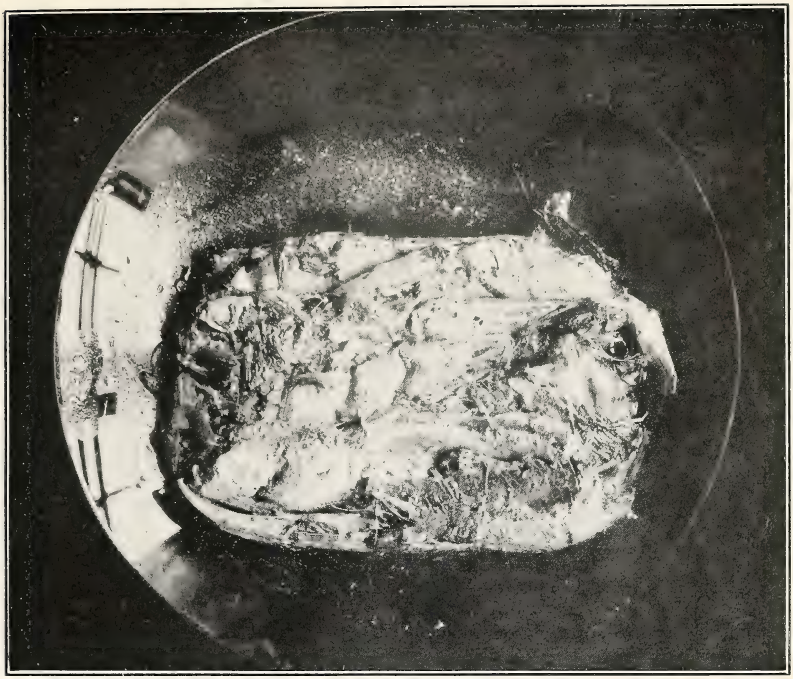

FIG. 1.—CAN OF QUARTER OIL SARDINES PACKED WITH FEEDY FISH.

It was packed backs up, thus concealing the condition shown on opening the can.

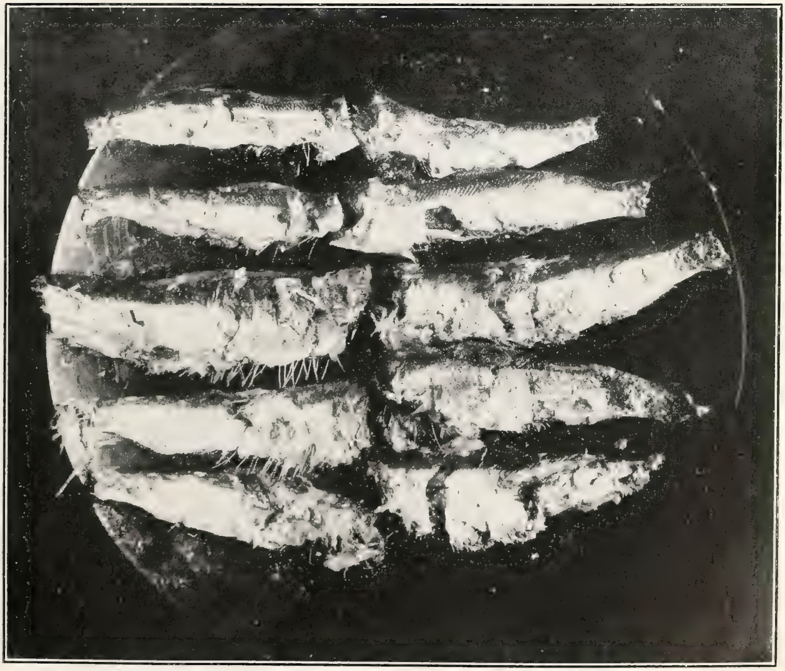

FIG. 2.—CONTENTS OF CAN OF SARDINES, SHOWING THE CHARACTERISTIC BELLY-BLOWN FISH, RESULTING FROM FEED.

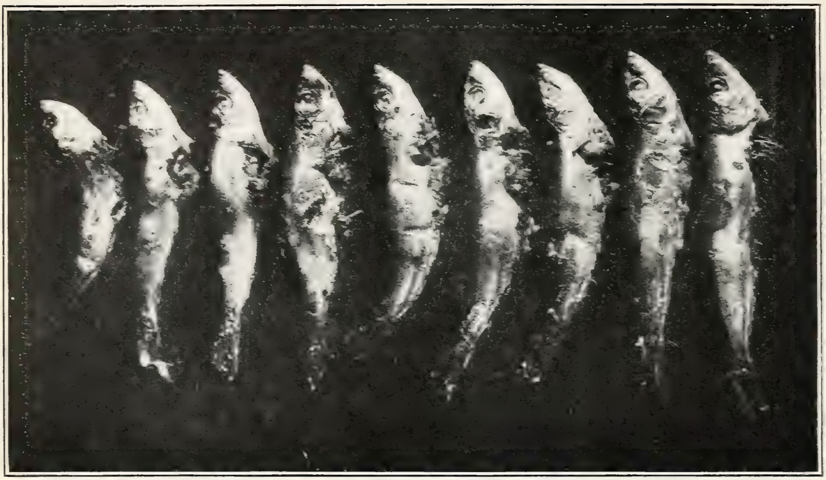

FIG. 1.—EFFECT OF RED FEED.

Every fish in a boatload may be like this when excessively feedy fish are taken.

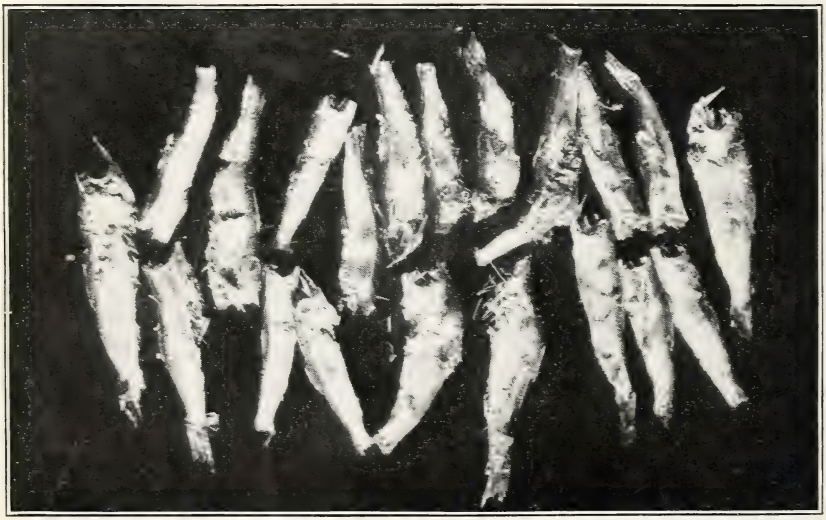

FIG. 2.—CONTENTS OF A CAN, REPRESENTING PACK OF GOODS ON A CERTAIN DAY, ILLUSTRATING THE DESIRE OF SOME PACKERS TO PRODUCE QUANTITY IRRESPECTIVE OF QUALITY.

Practically all the fish were belly broken from feed, and were literally thrown into the cans, no attention being paid to producing a neat appearing can.

The results obtained (Table 26) show that a sufficient amount of water was abstracted from the fish in all cases except one. Less water was removed in the cannery equipped with the kiln drier than in those equipped with the air drier, and much less than in the one equipped with the Ferris wheel drier. In Cannery E, equipped with an air (tunnel) drier, practically no water was removed. Throughout the test, as the results indicate, very little attention was shown in this cannery to the important feature of drying. It is apparent that the air driers, with the exception of that in Cannery E, and the kiln drier removed a sufficient quantity of water, while the plant equipped with the Ferris wheel oven drier did not. The degree of dryness of the fish on the next day on which samples were taken varies widely. On October 9, which was a rainy day, drying was not efficient, scarcely enough in any of the canneries to remove the proper amount of water from the fish before packing.

These results indicate that a great variation in the degree of drying sardines existed among the different canneries on the same day. It is probable also that variations in the degree of dryness of the fish exist in the same factory on the same day.

INTERMITTENT DRYING.

The practice of intermittent drying, adopted by a few canneries in the preparation of mustard size fish, consists in allowing the larger fish to stand for a period of from 8 to 10 hours after the first drying, and then drying them for an additional hour or so just prior to packing. This should be done only in the case of cut and eviscerated fish and those which have been handled in a sanitary manner, because of the possibility of the development of bacteria in the viscera and contents of uncut fish (p. 86). Fish which have not been cut and eviscerated should not be permitted to stand in the driers overnight, as moist fish furnish an excellent medium for the growth of bacteria.

EFFECT OF CUTTING AND EVISCERATING THE FISH.

It was found that the drying process was aided by cutting and eviscerating the fish, particularly those of mustard size. Drying is thus facilitated by the removal of the large amount of water in and surrounding the viscera, which is particularly difficult to drive off from the uncut fish.

CONCLUSIONS.

The factors in drying which can be controlled by the canners and which are essential in obtaining a uniform degree of dryness are an even, thin flaking of the fish, the volume and temperature, within proper limits, of the air, in the tunnel type of drier, and the time of drying. Too high a temperature of the oven or of the air used in drying must be avoided on account of the resulting loss of oil from very fat fish and for fear of scorching the product. The degree of heat which may be employed in drying is therefore limited; otherwise it would be possible to overcome the difficulty of drying on excessively humid days by raising the temperature of the drying medium sufficiently to obtain the desired results regardless of the humidity. Air should be taken from a source that will not carry particles of dirt to cause contamination of the fish.

It is believed that a great deal of the difficulty experienced in packing the three-quarter mustard sardines is due to insufficient drying. Fish that are packed too wet or too "green" become soft upon standing, and the mustard sauce often becomes discolored. If the cans should happen to be packed too full, resulting in a "fat can," they are likely to be rejected, particularly if on opening (cutting) the contents are found in the condition described.

All fish for mustard sardines should be cut and eviscerated. The fact that fish of this size are packed in a sauce containing from 85 to 90 per cent of water makes it necessary to dry them a great deal more than fish packed in oil. In some cases it is the practice to allow mustard size fish to stand overnight, after a preliminary drying, and complete the operation just before packing.

It is also well to have no more than a sufficient number of racks of fish out of the drier on the packing room floor, as the fish after being dried, particularly on a rainy day, absorb enough water to make their handling very difficult. It is practically impossible to prevent breaking of the skin of fish when handling them after they have absorbed water on standing.

The fish should be separated according to their size, so that the smaller fish need not remain in the driers as long as the larger ones.

Probably 90 per cent or more of the Maine sardines are packed from fish which have been steam cooked. Attention, therefore, to drying and its better control will have a marked effect on the quality of the product.

Much still remains to be done in studying the conditions of drying sardines as packed in this region. Investigations might profitably be undertaken with the object of establishing, for example, the proper time of drying, the maximum temperature, and the requisite volume of air (in the tunnel type of drier) under varying degrees of humidity.

PACKING THE FISH.

The packing of sardines differs from that of most food products put up in cans, in that it is necessary to arrange the small fish carefully to insure an attractive looking finished product. No other foodstuff requires the same skill or technique in the matter of being placed in their containers. From the selling point of view it is most important that sardines be properly packed.

Several photographs illustrating the appearance of the contents of cans when packed with varying degrees of care and skill were taken. The cans of sardines from which these photographs were made were obtained at random from different canneries. While the illustrations of the better appearing packs must not be regarded as representative of the best packing to be found in the Maine sardine industry, they indicate the kind of packing that should be demanded in the ''standard'' grade of Maine sardines.

Figure 1, Plate XVI, shows two cans of well packed sardines, brights up, contrasted with poorly packed cans that were packed backs up. Carelessness in the packing process was responsible for the inferior appearance of the unattractive can. The cans in figure 2 were well packed, but the fish had been roughly handled on the flakes, causing breaking of the skin and other damage.

Plate XVII is fairly representative of well packed cans, contrasted with poorly packed cans. Figure 1 shows two cans packed the same day with fish from the same weir, but at different canneries. The cans were taken from the packing table before being oiled. The superiority of the cans at the left was typical of the entire product of the cannery at that time, and did not represent any special degree of perfection in packing. Figure 2 shows the cans taken in the shipping room from the same lot as the well packed cans shown in figure 1 after they had been oiled, sealed, and sterilized. The disarrangement of the fish in the cans was caused by rough handling received by the cans during the processing and the subsequent handling. The mussy appearance of the fish is due to the presence of particles from the gills of snipped fish and material from the stomach and intestines. Figure 3 depicts three cans from the lot of poorly packed goods shown in figure 1 after they had been taken from the shipping room. The complete disarrangement of this slack and poorly packed can is due to rough handling. One of the cans selected proved to be a 3-fish can, showing the lack of grading on the basis of the number of fish per can (p. 96). These sardines also illustrate the utter lack of standardization on a quality basis.

The kind of goods that brings the Maine sardine into disrepute is shown in figure 2, Plate XIX. Practically all of the fish used for this pack were belly-broken, from the action of feed, and were literally thrown into the cans, with no effort to secure a neat appearance. The fault here is not entirely the packer's, as there is no incentive to pack carefully when material of such inferior quality is permitted entry into the cannery.

The conditions responsible for the quality of sardines, as represented in these photographs, can be attributed to (*a*) lack of uniformity of opinion as to what shall constitute a fair quality of sardines, (*b*) lack of desire on the part of a few to produce any standard quality, and (*c*) a lack of control over the employees. Sardines of the poorest quality are packed in canneries where the methods are inefficient and haphazard, and where very little, if any, supervision is exercised over the labor.

Rough Treatment.

At several points in the handling of fish preparatory to packing the fish receive too rough treatment. For instance, they may be scooped from the boats after having settled in a solid mass, whereas the best practice is to float them well in the hold of the boats before bailing them out. Another source of damage is the pulling and mauling the fish receive while on the flakes, particularly when too thickly flaked.

After the fish are packed in the cans the rough treatment the cans and contents receive has a direct bearing on the final appearance of the sardines. In many cases it was found that the operators in placing the cans upon the tail of the sealing machine inserted their fingers in the packed cans, thus disarranging and marring the contents. Sometimes a few cans become crushed, or some trouble with the sealing machine causes spilling. The fish thus lost are repacked, at the close of the day's sealing, constituting an inferior product because of the careless manner in which the sealer, unskilled in packing, does the work. Other commonly found instances of rough treatment are:

Permitting the cans to fall a distance of from 2 to 3 feet from the sealing machine after the covers have been attached.

The bailing of cans from the "bath" tanks with scoopnets and forcibly throwing the cans on the floor of the cannery.

Shoveling the cans over in drying and cleaning them with sawdust.

Tumbling and rattling the cans through revolving sawdust cleaners.

Shoveling and rolling the cans down too sharply inclined chutes to the shipping rooms.

Such treatment not only disarranges the fish within a well-packed can, but it may dent the seams of the cans, causing leaks.

Those packers who maintain a definite quality and who take pains to pack the fish neatly and attractively in the cans clean the exterior of the cans, before shipping, in a careful manner to prevent disarrangement of the contents.

ADDING THE OIL.

Quantity of Oil per Case.

A series of experiments were conducted on fish of different fat contents, packed in oil at the rate of 1 quart, 1½, 2, 2½, 3, 3½, and 4 quarts per case of 100 cans. Four packs were prepared in quarter oil size key cans. Fish of uniform size were selected from the flakes in the packing room, at the end of the steaming and drying process. The oil was run into each can from a pipette graduated to deliver the proper quantity. After allowing enough time to permit all the oil possible to soak into the fish the covers were sealed on the cans. Different types of sealing machines were used, but no provision was made to guard against leaks, such as the use of a gasket or by soldering.

In putting up the fish used for lot 4 a small patented packing device[1] was used. Some of the advantages claimed for this device, however, could not be checked in this experiment, owing to leakage of oil from the cans.

After these lots had been packed, oiled, processed, and allowed to stand for from 2 to 3 months, the contents of two representative cans from each lot were ground and thoroughly mixed. The oil was wiped out as completely as possible from the interior of the cans with the ground meat, and every effort was made to have each sample uniform. Three separate samples of the two cans from each pack were analyzed, the water, fat, and total nitrogen analyses being made in triplicate. The percentage amount of oil recovered, and the total food value per can, expressed in calories, were calculated from these results. In calculating the weight of oil added, the specific gravity of cottonseed oil was taken as 0.925. To determine the average weight of the fish per can, several lots of 100 fish each were weighed and an average taken. The results of these analyses are shown in Table 27.

The cans of lot 1 to which oil had been added at the rate of 1 and 1½ quarts per case contained only a trace of visible oil when opened. Those to which oil had been added at the rate of 2 quarts per case were less than one-quarter full of free oil, while those having oil added at the rate of 2½ quarts per case were less than half full. Cans to which the oil had been added at the rate of 3 quarts per case showed a reasonable amount, being about five-eighths full. At the rate of 3½ quarts, the cans were practically seven-eighths full, while those that were packed at the rate of 4 quarts per case were found to be practically full of oil.

The figures for the recovery of the added oil vary widely, owing to loss of oil at the time of sealing full cans and to loss on standing through imperfect seams. In all instances the percentage amount of oil recovered when the sardines were oiled at the rate of 4 quarts per case was low. These figures agree with observations made at the time of sealing and with the experience of the packers that when the cans are full, or almost full, of oil a great deal of it is expelled when the lid is forced down by the chuck during the sealing operation.

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[1] U. S. Letters Patent 1,206,977.

TABLE 27.—*Composition of sardines packed in varying amounts of oil.*

Amount of oil per case.	Total net weight (2 cans).	Water.	Fat.	Total nitrogen.	Total protein (Nx6.25).	Oil added per can.		Total weight of oil found.	Oil recovered.			Calories per can.		Oil visible in cans on opening.
									Sample (2 cans).	Average.		Total (2 cans).	Average per can.	
	Grams.	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Cc.*	*Grams.*	*Grams.*	*Grams.*	*Grams.*	*Per cent.*			
Lot 1:														
8 fish per can; from flakes; not packed.	[1] 168.00	61.86	6.03	....	....	....	....	10.15	....	....	....	....	....	
Oil at rate per case of—														
1 quart (25 per cent gallon).	171.00	56.94	15.79	3.60	22.50	9.50	8.79	27.00	16.85	16.93	96.3	397	201	Trace.
	188.00	58.79	14.00	3.52	22.00	9.50	8.79	26.32	16.17			402		
	177.00	56.90	15.72	3.58	22.37	9.50	8.79	27.92	17.77			408		
1½ quarts (37½ per cent gallon).	186.00	56.22	17.27	3.44	21.50	14.00	12.95	32.02	21.97	24.05	92.9	449	232	Do.
	185.00	54.88	19.65	3.28	20.50	14.00	12.95	36.35	26.20			479		
	189.00	56.28	18.06	3.30	20.62	14.00	12.95	34.13	23.98			463		
2 quarts (50 per cent gallon).	178.00	48.70	25.50	3.44	21.50	19.00	17.58	45.39	35.24	33.77	96.1	561	280	Less than one-fourth full.
	200.00	51.79	20.81	3.34	20.87	19.00	17.58	41.62	31.47			541		
	195.00	49.33	22.95	3.53	22.06	19.00	17.58	44.75	34.60			575		
2½ quarts (62½ per cent gallon).	191.50	47.64	26.97	3.27	20.44	23.70	21.93	51.65	41.50	44.17	100.0	621	324	Less than half full.
	195.50	47.10	29.15	3.28	20.50	23.70	21.93	56.99	46.84			673		
3 quarts (75 per cent gallon).	203.50	47.96	26.99	3.10	19.37	28.50	26.36	54.92	44.77	48.69	92.3	652	345	About five-eighths full.
	201.00	46.28	30.26	3.18	19.88	28.50	26.36	60.82	50.67			707		
	203.00	45.69	29.94	3.26	20.38	28.50	26.36	60.78	50.63			712		
3½ quarts (87½ per cent gallon).	201.50	42.02	35.06	3.15	19.69	33.00	30.53	70.65	60.50	56.92	93.2	794	388	About seven-eighths full.
	211.00	43.94	32.68	3.16	19.75	33.00	30.53	68.95	58.80			782		
	202.50	45.20	30.43	3.13	19.56	33.00	30.53	61.62	51.47			753		
4 quarts (100 per cent gallon).	218.50	42.93	32.96	3.08	19.25	38.00	35.15	72.02	61.87	62.75	89.3	816	412	Practically full.
	229.50	43.18	33.36	3.04	19.00	38.00	35.15	76.56	66.41			863		
	215.50	43.70	32.55	3.04	19.00	38.00	35.15	70.14	59.99			795		
Lot 2:														
5 fish per can; from flakes; not packed.	[2] 175.60	55.54	12.94	....	....	....	....	22.72	....	....	....	....	....	
Oil at rate per case of—														
1 quart (25 per cent gallon).	191.50	49.40	23.03	3.65	22.81	9.50	8.79	44.14	21.42	20.82	118.0	571	291	Less than one-fourth full.
	210.50	49.63	20.83	3.68	23.00	9.50	8.79	43.85	21.13			588		
	216.00	51.30	19.74	3.77	23.56	9.50	8.79	42.64	19.92			587		
1½ quarts (37½ per cent gallon).	201.50	50.13	22.57	3.61	22.56	14.00	12.95	45.48	22.76	23.69	91.47	591	304	Little over one-fourth full.
	198.00	51.21	21.87	3.56	22.25	14.00	12.95	43.30	20.58			566		
	226.00	49.68	22.33	3.63	22.69	14.00	12.95	50.46	27.74			666		

2 quarts (50 per cent gallon).	193.00	48.67	26.94	3.38	21.12	19.00	17.58	51.99	29.27	33.62	95.65	631	341	About half full.
	219.00	46.97	27.34	3.41	21.31	19.00	17.58	59.87	37.15			725		
	204.00	46.34	28.02	3.38	21.12	19.00	17.58	57.16	34.44			687		
2½ quarts (62½ per cent gallon).	214.00	45.09	30.70	3.25	20.31	23.70	21.93	65.70	42.98	40.38	92.09	765	375	Over half full.
	227.00	46.94	28.07	3.38	21.12	23.70	21.93	63.72	41.00			765		
	208.50	46.03	28.72	3.43	21.44	23.70	21.93	59.88	37.16			718		
3 quarts (75 per cent gallon).	230.50	45.22	29.78	3.45	21.56	28.50	26.36	68.64	45.92	48.15	91.32	816	410	Nearly full.
	220.00	44.29	31.41	3.23	2 .19	28.50	26.36	71.30	48.58			819		
	214.00	43,70	33.97	3.27	20.44	28.50	26.36	72.69	49.97			829		
3½ quarts (87½ per cent gallon).	223.00	41.92	34.01	3.26	20.37	33.00	30.53	75.84	53.12	49.95	81.82	864	419	Do.
	228.50	45.94	29.22	3.28	20.50	33.00	30.53	66.77	44.05			788		
	234.50	42.32	32.16	3.16	19.75	33.00	30.53	75.41	52.69			864		
4 quarts (100 per cent gallon).	222.50	44.15	33.62	3.02	18.87	38.00	35.15	74.80	52.08	61.93	88.05	841	469	Full.
	230.00	38.69	36.63	3.04	19.00	38.00	35.15	84.25	61.53			933		
	242.50	37.22	39.14	3.07	19.19	38.00	35.15	94.91	72.19			1,040		
Lot 3:														
12 lean, small fish per can; from flakes; not packed.	[3] 153.80	59.13	7.94	....	....	....	....	12.21	....	....	....	....	....	
Oil at rate per case of—														
1 quart (25 per cent gallon).	179.00	54.45	14.56	3.75	23.44	9.50	8.79	26.05	13.84	12.96	73.72	402	194	No oil present.
	160.50	53.35	14.88	3.85	24.06	9.50	8.79	23.88	11.67			369		
	168.50	53.89	15.18	3.85	24.06	9.50	8.79	25.58	13.37			392		
1½ quarts (37½ per cent gallon).	181.50	52.44	18.29	3.66	22.87	14.00	12.95	33.19	20.98	19.06	73.59	465	221	Trace.
	168.50	51.90	16.58	3.87	24.19	14.00	12.95	27.94	15.73			414		
	169.50	50.09	19.29	3.73	23.31	14.00	12.95	32.69	20.48			452		
2 quarts (50 per cent gallon).	226.50	53.06	20.23	3.54	22.12	19.00	17.58	45.82	33.61	26.02	74.03	613	264	Do.
	166.50	44.38	22.18	4.19	26.19	19.00	17.58	36.93	24.72			507		
	177.00	48.75	18.06	3.99	24.94	19.00	17.58	31.96	19.75			464		
2¾ quarts (69½ per cent gallon).	195.00	45.48	25.66	3.58	22.37	26.30	24.33	50.03	37.82	43.64	89.68	625	328	One-third full.
	197.50	43.38	29.15	3.43	21.44	26.30	24.33	57.57	45.36			687		
	224.00	47.49	26.77	....	....	....	....	59.96	47.75					
3 quarts (75 per cent gallon).	216.00	44.91	26.73	3.27	20.44	28.50	26.36	57.73	45.52	44.18	83.79	696	343	Less than half full.
	207.50	44.65	27.26	3.49	21.81	28.50	26.36	56.56	44.35			690		
	207.00	45.62	26.51	3.45	21.56	28.50	26.36	54.87	42.66			672		
3½ quarts (87½ per cent gallon).	225.50	46.34	28.55	3.06	19.12	33.00	30.53	64.38	52.17	52.88	86.62	752	383	Half full.
	230.00	44.42	28.46	3.37	21.06	33.00	30.53	65.46	53.25			783		
	208.50	41.53	31.38	3.29	20.56	33.00	30.53	65.43	53.22			760		
4 quarts (100 per cent gallon).	193.00	36.50	38.68	3.15	19.69	38.00	35.15	74.65	62.44	57.79	82.21	824	407	About three-fourths full.
	205.50	39.40	34.76	3.33	20.81	38.00	35.15	71.43	59.22			814		
	185.50	34.46	38.93	3.32	20.75	38.00	35.15	72.21	51.71			804		

[1] Average weight of 16 unpacked fish.

[2] Average weight of 10 unpacked fish.

[3] Average weight of 24 unpacked fish.

TABLE 27.—*Composition of sardines packed in varying amounts of oil*—Continued.

Amount of oil per case.	Total net weight (2 cans).	Water.	Fat.	Total nitrogen.	Total protein (Nx6.25).	Oil added per can.		Total weight of oil found.	Oil recovered.			Calories per can.		Oil visible in cans on opening.
									Sample (2 cans).	Average.		Total (2 cans).	Average per can.	
Lot 4:	*Grams.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Cc.*	*Grams.*	*Grams.*	*Grams.*	*Grams.*	*Per cent.*			
6 very fat fish per can; from flakes; not packed.	[1] 164.60	55.76	16.00					26.34						
Oil at rate per case of—														
1 quart (25 per cent gallon).	178.50	55.37	19.74	3.34	20.87	9.50	8.79	35.23	8.89	8.19	46.59	466	226	None.
	150.50	51.51	22.21	3.54	22.12	9.50	8.79	33.43	7.09			434		
	160.00	51.36	21.84	3.53	22.06	9.50	8.79	34.94	8.60			455		
1½ quarts (37½ per cent gallon).	187.00	53.02	22.17	3.43	21.44	14.00	12.95	41.46	15.12	14.94	57.69	533	263	Trace.
	184.50	52.22	22.20	3.41	21.31	14.00	12.95	40.96	14.62			526		
	168.00	50.31	24.67	3.52	22.00	14.00	12.95	41.44	15.10			521		
2 quarts (50 per cent gallon).	176.50	45.05	31.33	3.10	19.37	19.00	17.58	55.30	28.96	28.36	80.68	634	325	Less than one-fourth full.
	219.50	51.62	23.84	3.26	20.37	19.00	17.58	52.33	25.99			650		
	191.50	46.30	29.49	3.24	20.25	19.00	17.58	56.48	30.14			663		
2½ quarts (62½ per cent gallon).	192.00	47.30	28.39	3.28	20.50	23.70	21.93	54.51	28.17	27.64	63.04	648	315	One-fourth full.
	175.50	43.63	33.70	3.13	19.56	23.70	21.93	59.14	32.80			669		
	181.50	43.01	26.61	3.14	19.62	23.70	21.93	48.30	21.96			577		
3 quarts (75 per cent gallon).	192.00	44.49	32.35	3.18	19.87	28.50	26.36	62.11	35.77	33.63	63.78	711	348	Half full.
	190.50	43.97	31.94	3.43	21.44	28.50	26.36	60.84	34.50			711		
	191.00	47.09	29.83	3.21	20.06	28.50	26.36	56.97	30.63			666		
3½ quarts (87½ per cent gallon).	201.00	41.29	35.83	3.24	20.25	33.00	30.53	72.02	45.68	40.28	65.98	811	385	Less than three-fourths full.
	215.50	47.63	29.88	3.16	19.75	33.00	30.53	64.39	38.05			750		
	226.50	46.31	28.02	3.19	19.94	33.00	30.53	63.46	37.12			752		
4 quarts (100 per cent gallon).	223.00	43.57	34.28	3.14	19.62	38.00	35.15	76.44	50.10	47.25	67.21	854	409	Three-fourths full.
	184.00	39.03	38.30	3.09	19.31	38.00	35.15	70.47	44.13			776		
	215.50	43.00	34.28	3.15	19.69	38.00	35.15	73.87	47.53			824		

[1] Average weight of 12 unpacked fish.

The influence of the increasing quantities of oil on the food value of a can of sardines is indicated in the column of Table 27 which shows the total calories per can. These figures are the average results of the analysis of six cans. The food value of the sardines composing lot 1 to which a minimum amount of oil was added was 201 calories per can, and that of those to which the maximum amount of oil was added (at the rate of 4 quarts per case) was 412 calories per can.

The fish composing lot 2 were much fatter than the Castine fish used for lot 1. The influence of the fatness of the fish on the oil present on opening the cans is shown. The cans which were oiled at the rate of 3 quarts per case were nearly full, as were also those oiled at the rate of 3½ quarts per case. The cans packed at the rate of 4 quarts of oil per case were full of oil. The percentage recovery of oil was much less when the cans were oiled at the rate of 3½ and 4 quarts than when smaller amounts of oil were added. To avoid this loss, many packers do not add enough oil to make a good showing when the can is opened. This is particularly true in cases where the pack is composed of lean fish and where the oiling device is attached to the sealing machine, allowing insufficient time for the oil to be absorbed by the fish before some of it is squeezed out of the can during the sealing operation. The resulting loss due to the method of oiling and that due to poorly sealed cans which "weep" oil after sealing are conditions which should be remedied in order to avoid waste of oil. Not only is oil lost in this way but the product also loses in food value. In this lot, at the rate of 1 quart of oil per case, the average number of calories per can was 291, while at the rate of 4 quarts per case the average was 469. The figures for the calories at the other rates of oiling increased as the amount of oil increased.

The cans of lot 3, even those containing fish which had been oiled at the rate of 4 quarts per case, were only about three-quarters full of oil. These cans were poorly sealed, and consequently lost oil during processing and while standing, as is shown by the fact that an average of only 80.52 per cent of oil was recovered for all the packs in this lot. The food value is also low as compared with that of lot 2.

The fish used in lot 4 were very fat, containing 55.76 per cent of water and 16 per cent of fat. The cans packed at the rate of 4 quarts per case were only three-quarters full of oil when opened. Considering the care taken in packing, the percentage amount of oil recovered was small. On the other hand, the food value agreed very well with that of the other packs and showed the same variations according to the quantity of oil present. That the food value was correspondingly high was due to the fatness of these fish. An inspection of the rest of the cans of this pack showed that they had leaked badly while stored in the shook. The cans were very unsightly, being covered with oil, and, in many cases, stuck together with the partially dried oil. The analyses showed that practically one-third of the oil added had leaked through the seams of the cans.

From these experiments it seems fair to conclude that the proper amount of oil per case to add to sardines is 3 quarts (75 per cent of a gallon) for average fat fish and 3½ quarts (87.5 per cent of a gallon) for lean fish of poor quality. These quantities allow for possible unavoidable losses in oil during the sealing process. The oil in these amounts can readily be added to the standard quarter oil can without loss, if time be allowed for the absorption of oil before the cover is sealed on the can.

KIND OF OIL.

TESTS WITH CORN OIL.

As has already been stated, cottonseed oil is the oil most widely used in packing Maine sardines. During the season of 1913 the possibilities of the use of corn oil for packing sardines were investigated. The oil in corn is contained in the embryo or germ, which is separated from the rest of the kernel in the manufacture of starch, glucose, etc. The germ is heated and the oil expressed and then refined. It is a neutral, bland oil, with practically no characteristic taste. It does not, therefore, mask the flavor of the fish which are packed in it. At the time these experiments were made corn oil was cheaper than cottonseed oil. Under normal conditions, corn oil is said to sell for from 5 to 10 cents a gallon less than cottonseed oil, which should make it worthy of consideration by the sardine packers. In normal times enough refined corn oil may be had to supply the entire sardine industry.

Inquiry among the packers showed that, in previous experience, corn oil had proved generally unsatisfactory. At the time the packers had tested this oil it was the practice in all the canneries to fry the fish in oil. When the corn oil was tried out in the frying vats it gave off a disagreeable odor and foamed so badly that it boiled out of the vats. Within the last few years the process of refining has been improved, so that a fine grade of oil, much superior to that formerly marketed, can now be had. The highly refined oil was secured for the tests here reported.

BEHAVIOR ON HEATING.

Corn oil, summer yellow cottonseed oil, and winter yellow cottonseed oil, 100 to 150 cc (3 to 5 ounces) of each, were heated in beakers over the flame, stirring constantly with a thermometer, with the following results:

Corn oil did not boil at 265° C. (509° F.). An odor not disagreeable and hardly characteristic of corn appeared at about 150° C. (302° F.). At 230°–240° C. (446°–464° F.) copious fumes with a slightly irritating, pungent, penetrating odor appeared.

Summer yellow cottonseed oil did not boil at 265° C. (509° F.). A characteristic odor appeared at 165° C. (329° F.). Fumes, slight in quantity compared with corn oil, but more penetrating, appeared at 245° C. (473° F.).

Winter yellow cottonseed oil did not boil at 265° C. (509° F.). A slight characteristic odor appeared at 160° C. (320° F.). Fumes, slight in amount and with no more odor than that obtained from the oil when heated at 160° C., appeared at 250° C. (482° F.).

The results of these tests show that corn oil of the quality represented by these samples compares favorably with cottonseed oil. It does not stand heating to a high temperature quite as well as the winter yellow variety, but is equal, if not superior, to the summer yellow grade, particularly when heated at a lower temperature, around 150° to 165° C. (302° to 329° F.). Apparently corn oil breaks down a little more rapidly when heated at the higher temperatures.

When tested by the Kreis reaction for rancidity upon exposure to the air, each oil gave a negative test at first. On standing in uncovered beakers for one and two days, corn oil failed to show a test for rancidity at the expiration of 24 hours, the winter yellow cottonseed oil gave a positive test at the end of 24 hours, and the summer yellow cottonseed oil gave an intensely positive test. At the end of 48 hours the corn oil showed only a slight positive test for rancidity by this reaction, while both the winter and summer yellow oils were intensely positive. With respect to the development of rancidity on exposure to the air, corn oil appears to be far superior to cottonseed oil.

EFFECT ON FLAVOR OF SARDINES.

During the seasons of 1913 and 1914 a number of small packs using various kinds of oil—raisin, olive, peanut, winter yellow cottonseed, summer yellow cottonseed, and corn—were made. Tests with the raisin oil were at once abandoned, as its odor and sweet flavor made it entirely unsuited for use with fish. All the methods of packing in vogue at that time were employed, as well as the process of baking the fish before packing them. Samples of the packs in these oils, with the exception of raisin oil, were submitted to different people for an opinion as to the quality and taste, the samples submitted to each person or group being selected from the same pack, in which the source and treatment of the fish were identically the same, with the exception of the kind of oil used.

By all but one or two the samples packed in corn oil were pronounced superior to those packed in cottonseed oil. Some even preferred the corn-oil to the olive-oil pack. Eliminating the olive-oil packs from consideration, there was no question of the superiority of the corn-oil packs in the rich flavor imparted to the fish and the absence of any characteristic taste of the oil. The flavor of the fish in the corn-oil packs was not masked by the oil, but rather improved by it. In most cases, the winter-pressed oil was pronounced second in quality to corn oil, prime summer yellow oil being classed third.

The packs composed of baked fish and of fish fried in oil were far superior to the products prepared by other methods which did not bring out the delicate fish flavor. The better flavor of the fish, developed by frying or baking, may be conserved for the canned product by the use of corn oil.

Canneries equipped with the so-called Ferris wheel driers can utilize this equipment to excellent advantage by grilling the fish before frying and packing them, thus attaining the very best flavor.

EFFECT ON APPEARANCE OF SARDINES.

It was found also that in packing sardines in corn oil or the better grade of cottonseed oil, stearin did not settle out during cold weather. Sardines packed in prime summer yellow cottonseed oil when opened in cold weather present a very unattractive appearance, due to the white film or mass of stearin over the fish. It would seem wise, therefore, to pack sardines for shipment into cold climates in the winter-pressed variety of cottonseed oil or in corn oil and use prime summer yellow cottonseed oil for goods going to warm regions.

Tomato Sauce.

Sardines in tomato sauce have not been packed in Maine to any great extent. During the season of 1913 an attempt was made by one of the canning companies to pack a few cases in this way, but the undertaking proved unsuccessful. It is understood that several other companies are now packing a few sardines and herrings in tomato sauce. In consideration of the demand for this product, it is strange that herring and sardines in tomato sauce are not prepared in greater quantity in Maine. That no special difficulty is encountered in the process, and the product is very attractive, is shown by the fact that packers in other localities put out a great many cans of this article.

Mustard Sauce.

It has been estimated that 25 per cent of the season's pack of Maine sardines is put up in mustard sauce. A large part of the sauce used for this purpose is prepared in mustard sauce mills, owned and operated by the sardine companies. In one instance several companies operate a mustard sauce plant on a cooperative basis. Part of the sauce is prepared by an independent company located in one of the principal centers of the industry, and a certain amount is furnished by a well-known sauce and spice manufacturer. The results of the analysis of samples of the three sauces most widely used are given in Table 28.

TABLE 28.—*Composition of mustard sauce.*

Total solids.	Salt (NaCl).	Acid, as acetic.	Total nitrogen (N).	Total protein (N x 6.25).	Nitrogen in salt free solids.	Mustard and turmeric.[1]
Per cent.	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
11.83	3.36	3.12	0.395	2.47	4.67	6.00
12.00	4.49	1.42	.368	2.30	4.90	5.21
14.49	2.75	2.63	.523	3.27	4.46	8.47

[1] Total solids — (salt+protein).

In the preparation of the sauce represented by the second sample a smaller amount of vinegar, or one of weaker strength, was used, while in that of the sauce represented by the third sample a larger amount of mustard or turmeric was employed. These samples were also examined microscopically.[1] The first two samples contained a great deal of turmeric and more red pepper than is commonly found in a mustard sauce of this grade. The last one contained more turmeric than either of the other two and not quite as much red pepper. The amount of turmeric in this sauce is excessive, compared with that in the other two sauces.

PROCESSING THE SARDINES.

The method of processing or sterilizing the sealed packed cans by heating them in tanks of boiling water is practically universal in the Maine sardine industry. At the time these investigations were made one of the canneries employed for this purpose retorts in which the contents could be heated under pressure.

The length of time given to processing varied widely among the different canneries. The usual period was from 1¾ to 2¼ or 2½ hours, the variation depending on the size of the cans and the canner's idea of the time necessary for sterilization. An instance was found in which the canner was giving only one hour to processing in a tank of boiling water.

To obtain data which might be helpful in determining the length of time of processing, the temperature of the inside of cans of sardines, as ordinarily processed in boiling water baths, was determined. The results, given in Table 29, show the time necessary to raise the initial temperature of the inside of the can to practically the boiling point of water.

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[1] The examination was made by B. Silberberg, of the Microchemical Laboratory of the Bureau of Chemistry.

TABLE 29.—*Temperature of inside of can of sardines processed with regular lot.*

Near center of boiling tank.[1]		Near surface of water in boiling tank.[2]	
Time.	Temperature.	Time.	Temperature.
p. m.	*° C.*	*a. m.*	*° C.*
12.25	36	8.30	26
12.35	47	8.35	36
12.42	88	8.40	45
12.46	94.5	8.46	71
12.48	99	8.48	80
12.50	100	8.50	91
		8.52	99
		8.54	99
		8.58	99
		9.10	99.25

[1] This boiling tank was provided with a board cover which was lowered while processing the cans. The water was heated by steam passing through pipes in bottom of tank. It boiled freely during the period these temperatures were measured.

[2] Tank uncovered, heated by direct steam.

The length of time required to reach the boiling point varies with certain conditions commonly found. In this method of processing it is very important that the cans be completely submerged during the entire period. Since it was found that sardines were not always uniformly sterile, it would be safer to process for the longer periods of time.

STORING THE SARDINES.

A portion of each year's pack of sardines is stored for varying periods of time and under varying conditions before it reaches the consumer. When held by the packers the sardines are subjected to the rigid winters of Maine, as no suitable warehouse exists for storage, advantage being taken of cellars, wherever available. When shipped they are often frozen, only to be thawed out again upon coming into a warmer region, where they may be held at terminals or warehouses having relatively high temperatures. Finally, they may remain upon the retailer's shelves for some time, under varying temperature conditions.

Certain differences in the composition of canned sardines, when analyses were made directly after processing and after standing for different periods of time led to an investigation of the changes occurring in sardines kept under varying conditions of storage.

FORMATION OF AMMONIA AND AMINES.

The values for ammoniacal nitrogen in fresh and decomposed fish as determined by the Nessler method did not agree with the results obtained by the titration method. Noticeable increases in the amount of total ammoniacal material in packs of fish which had stood for a time over the amount of such material found in the same packs directly after being processed were also apparent.

Table 30 gives the results of the determinations of ammoniacal nitrogen in sardines stored for various periods of time.

TABLE 30.—*Ammoniacal nitrogen content of sardines stored for various periods.*

Condition of fish.	Period held.	Ammoniacal nitrogen per 100 grams.	
		Nessler.	Titration.
		Mg.	*Mg.*
Fresh		107.8	147.6
Do	24 hours	121.7	189.6
In pickle:			
½ hour	7 months		203.1
1 hour	do		206.1
1½ hours	do		204.5
½ hour	19 months		271.8
1 hour	do		239.4
1½ hours	do		223.0

From the nature of the material, coupled with the well-known fact that amines are formed in the decomposition of fish, fish brine being a source of trimethylamine, amines were naturally looked upon as responsible for the discrepancy between the values obtained by the two methods of analysis, and possibly were partly responsible for the increase in the ammoniacal nitrogen which occurs on standing. Evidently a change occurs in canned sardines on standing, substances having an alkaline reaction (amines), determined as ammonia by the titration method, being liberated. Unfortunately, the Nessler method for determining ammonia is not reliable in the presence of amines. The difference in the values obtained by the methods employed for ammonia, while giving some indication of the amount of amines present, is not even sufficiently accurate to warrant regarding it as an approximate measure of the amine content.

The interesting fact that older packs of sardines contain larger amounts of ammoniacal material than those which have stood for only a short time was definitely proved by analyzing samples of commercially packed sardines which had stood for 2, 4, and 6 years in a cellar where the temperature was practically uniform and never reached the freezing point. In these analyses determination of the total volatile nitrogen and "ammonia" by the Nessler method, as well as the separation of ammonia and amines in the total volatile material, were made.

On opening the cans the two brands which had been packed for 2 years were found to be in very good condition. The fish were slightly colored by what appeared to be iron from the lid of the can, which was badly detinned. The cans in the 4-year-old lot looked worse than any of the other samples. A large amount of a white, soft material, probably stearin from the oil, was spread over the fish. The fish in the cans of the 6-year-old lot were covered with the same soft, white material. These cans contained only a small amount of visible oil, and the fish adhered to the lid of the can when opened. The interior of the can was detinned to a greater extent in this lot than in any of the others. The results of these analyses are given in Table 31.

TABLE 31.—*Ammonia and amine content of sardines after long periods of storage.*

Condition of fish.	Water.	Fat.	Total volatile nitrogen (N) per 100 grams, by—			Total volatile nitrogen (N) per 100 grams, as[1]—			Percentage of total as—		Appearance.
			Titration.	Nessler.	Difference.	Total.	Ammonia.	Amines.	Ammonia.	Amines.	
	P. ct.	*P. ct.*	*Mg.*	*Mg.*	*Mg.*	*Mg.*	*Mg.*	*Mg.*	*P. ct.*	*P. ct.*	
Best grade, packed[2] and held 2 years.	55.88	20.73	46.6	17.3	29.3	46.9	20.1	26.8	42.9	57.1	Good; slightly colored, apparently by iron; lid badly detinned.
	54.15	21.76	40.8	17.4	23.4	46.6	15.6	31.0	33.5	66.5	
Poorer grade, packed and held 2 years.	57.08	18.73	39.6	14.7	24.9	44.7	17.8	26.9	39.8	60.2	Particularly bright and firm.
	55.40	20.95	43.1	18.9	24.2	37.7	5.0	32.7	13.3	86.7	
Packed and held 4 years.	50.01	33.60	33.8	14.0	19.8	37.2	5.9	31.2	15.9	84.1	Very poor; soft white material, probably stearin, spread over fish.
	.....	.....	.....	.....	.....	45.9	6.4	39.5	13.9	86.1	
Packed and held 6 years.	57.75	21.94	60.6	14.9	45.7	51.1	8.6	42.5	16.8	83.2	Poor, covered with white material; small amount of visible oil; fish adhered to lid; large amount of detinning.
	.....	.....	.....	.....	.....	69.3	.....	(3)	.....	.....	

[1] Determinations and separations made on 50-gram samples.
[2] Determinations made on 3-gram samples.
[3] Lost.

The results show that a change in the relative amount of ammonia and amines occurred, the degree depending on the time the fish remained in storage. The total amount of alkaline material was quite constant in the 2-and 4-year-old goods, but increased noticeably in the 6-year-old pack. The quantity of ammonia, both in the actual amount obtained and in the percentage of the total volatile nitrogen, decreased, while the amines increased directly with the age of the goods. Eliminating one determination, which shows a very low ammonia content on the 2-year-old packs, the average percentage amount of the total was 38.7, while the three determinations on the 4-and 6-year-old packs showed only 15.5 per cent of the total alkaline material as ammonia, with a corresponding increase of from 61.3 to 84.5 per cent, respectively, in nitrogen as amines.

An experiment was conducted to ascertain whether these changes in the canned fish could be followed during shorter periods of standing at ordinary room temperature. A pack of a little more than half a case of quarter oils was made from fish which had just been landed at a cannery, and had been only a short time in brine. After being steamed and dried, under ordinary commercial conditions, these fish were taken to the laboratory, where the heads were removed, and the portion used for packing ground and thoroughly mixed. A representative sample was reserved for analysis and the remainder was packed in cans which were sealed and processed for 1¾ hours at 212° F. Samples taken at varying periods were analyzed, with the results shown in Table 32.

TABLE 32.—*Ammonia and amine content of sardines stored for short periods.*

Condition of fish (ground flesh).	Water.	Fat.	Total volatile nitrogen (N) per 100 grams.	Volatile nitrogen (N) per 100 grams as—			Percentage of total as—	
				Total.	Ammonia.	Amines.	Ammonia.	Amines.
	Per cent.	*Per cent.*	*Mg.*	*Mg.*	*Mg.*	*Mg.*	*Per cent.*	*Per cent.*
Before packing in quarter oil cans	67.01	9.07	14.0	[1] 13.3	7.4	5.9	55.6	44.4
After packing and processing 1¾ hours at 212° F	65.75	9.13	30.3	[1] 39.7	25.3	14.4	63.6	36.4
After packing, processing, and standing—								
1 month	65.85	9.02	42.0	[1] 46.8	27.2	19.6	58.1	41.9
2 months	67.00	8.72	47.8	[1] 47.3	22.6	24.7	47.8	52.2
3 months	66.40	8.69	52.5	[1] 53.1	24.2	28.9	45.6	54.4
4 months	66.64	8.18	55.0	[2] 54.3	25.9	28.4	47.7	52.3
6 months	66.25	9.23	55.6	[2] 55.6	19.1	36.5	34.3	65.7
18 months	64.79	9.93	69.0	[2] 69.0	35.8	33.2	51.9	48.1
36 months [3]				[2] 78.9	41.3	37.6	52.4	47.6
36 months [4]				[2] 82.4	44.0	38.4	53.4	46.4

[1] These determinations were made on the combined volatile alkaline nitrogen obtained from two 50-gram samples.

[2] These determinations were made on the combined volatile alkaline nitrogen obtained from thirty 3-gram samples.

[3] Normal cans.

[4] Swell cans, springers.

An increase in the amount of ammonia, with a corresponding decrease in the relative amount of amines, occurred during the processing. The actual amounts of both the ammonia and amines increased. Standing caused a gradual increase in the amount of total alkaline material obtained from the flesh, due to the formation of amines, the ammonia content remaining fairly constant, with the exception of the samples taken from the 6-months'-old pack, when a decrease in the amount of ammonia was noted.

The results expressed as percentage of the total volatile alkaline material point more clearly to a reduction in the quantity of ammonia, with a corresponding increase in the relative amount of amines, up to and including the 6-month period of standing.

The increase in total volatile material continued in the case of the cans stored for 18 and 36 months. A more marked increase over the amount found at the end of 6 months occurred during the last year and a half. The incipient swell cans contained but a slightly greater quantity of volatile alkaline material than the normal cans. The separation of ammonia and amines in the volatile alkaline material gave, in all three cases, results quite different from those obtained at the earlier periods of examination, particularly those of the 6-month period. After standing 18 and 36 months, the volatile alkaline material consisted of practically equal parts of ammonia and amines. The proportion of ammonia and amines in this pack, after the longer periods of standing, agreed closely with the results obtained on packs which were allowed to stand for an excessive length of time (Table 31).

INFLUENCE OF TIME AND TEMPERATURE OF STORAGE.

To determine the influence of the time and temperature of storage on the formation of ammonia and total amines in sardines, a number of packs were prepared from fish which had been subjected to widely diverse preliminary treatments. The fish used in the preparation of lots 1, 2, and 3 were dry salted at the rate of one-half sack of salt per hogshead of fish, when taken from the water, and were held in the salt for varying periods, as indicated in Table 33. Those composing lot 4 were surrounded with an ice and salt mixture during transportation and at no time were they in contact with salt or pickle. The fish of lot 5 were feedy fish, gorged with feed which did not look like shrimp. The fish were steam cooked, dried, packed without being eviscerated, and processed for 1¾ hours. As soon as the processed cans were cool, samples were prepared and analyzed. The rest of the packs were stored for different lengths of time at ordinary room temperature and at 33° F. When the analyses were made, the viscera of some of the fish were separated from the whole fish, so that determinations were made upon the whole fish, upon the eviscerated fish, and upon the viscera and contents. The results of these analyses are given in Table 33.

TABLE 33.—*Influence of time and temperature of storage on the formation of ammonia and amines in canned sardines.*

WHOLE FISH AS TAKEN FROM CAN.

Condition of fish.	Period held.	Period in dry salt.	Water.	Fat.	Volatile alkaline material as—							
					Nitrogen (N) per 100 grams.						Percentage of total.	
					Total.	Ammonia.	Amines.				Ammonia.	Total amines.
							Total.	Monamine.	Diamine.	Triamine.		
	Mos.	*Hrs.*	*P. ct.*	*P. ct.*	*Mg.*	*Mg.*	*Mg.*	*Mg.*	*Mg.*	*Mg.*	*P. ct.*	*P. ct.*
LOT 1:												
Packed and processed	0	4	53.07	20.87	38.2	24.8	13.4	......	......	......	64.9	35.1
Stored at room temperature.	3	4	56.94	18.19	41.5	......	......	......	......	......	......	......
Do	15	4	58.38	17.72	68.6	34.7	33.9	1.7	2.6	28.5	50.5	49.5
3 months at room temperature 12 months at 33° F	15	4	52.18	22.85	50.9	26.1	24.8	3.1	2.3	18.9	51.3	48.7
Stored at room temperature.	32	4	......	......	79.8	43.0	36.8	0.0	6.7	26.8	53.9	46.1
Stored at 33° F	32	4	......	......	62.1	26.6	35.5	0.0	6.1	28.8	42.5	57.5
LOT 2:												
Packed and processed	0	8	48.67	26.26	34.0	24.0	10.0	......	......	......	70.6	29.4
Stored at room temperature.	3	8	48.67	27.07	39.5	......	......	......	......	......	......	......
Do	15	8	47.58	26.93	61.9	......	44.5	2.5	2.8	37.1	......	......
Do	32	8	......	......	73.2	39.3	33.9	0.0	3.3	28.1	53.7	46.3
LOT 3:												
Packed and processed	0	25	49.13	27.80	35.1	23.7	11.4	......	......	......	67.5	32.5
Stored at room temperature.	3	25	52.41	22.84	48.6	......	......	......	......	......	......	......
Do	15	25	47.05	28.70	58.3	31.7	26.6	2.2	2.0	21.9	54.4	45.6
Do	32	25	......	......	76.7	44.5	32.2	0.0	3.4	26.5	56.7	43.3
LOT 4:												
Packed and processed	0	[1]4	59.83	19.64	32.5	22.7	9.8	......	......	......	61.0	39.0
Stored at room temperature.	2	4	60.061	18.84	40.7	......	......	......	......	......	......	......
Do	15	4	64.14	19.96	69.2	34.8	34.4	2.5	4.2	24.2	50.2	49.8
2 months at room temperature 13 months at 33° F	15	4	64.49	14.78	53.4	26.0	27.4	1.1	1.4	24.7	48.7	51.3
Stored at room temperature.	32	4	......	......	80.1	42.8	37.3	0.0	5.1	32.3	53.4	46.6
Stored at 33° F	32	4	......	......	56.9	27.1	29.8	0.0	5.8	23.7	47.7	52.
LOT 5 (FEEDY FISH):												
Packed and processed	0	6	58.82	23.75	25.4	15.0	10.4	......	......	......	59.1	40.9
Stored at room temperature.	2	6	50.21	28.19	38.7	......	......	......	......	......	......	......
Do	15	6	52.67	26.77	62.5	30.0	32.5	2.4	3.1	25.7	48.0	52.0
2 months at room temperature 13 months at 33° F	15	6	49.96	27.80	40.7	19.2	21.5	1.7	1.5	18.5	47.2	52.8
Stored at room temperature.	32	6	......	......	76.4	42.4	34.0	0.0	6.7	26.5	55.5	44.5
Stored at 33° F	32	6	......	......	49.8	22.4	27.4	0.0	5.1	22.3	45.0	55.0
FISH EVISCERATED WHEN TAKEN FROM CAN.												
LOT 1:												
Packed and processed	0	4	57.46	16.78	40.9	27.5	13.4	......	......	......	67.2	32.8
Stored at room temperature.	3	4	59.50	25.12	44.8	......	......	......	......	......	......	......
Do	15	4	55.09	20.18	61.3	45.8(?)	15.5	1.6	1.3	12.0	74.7	25.3
3 months at room temperature 12 months at 33° F	15	4	57.53	16.96	55.5	23.3	32.2	2.0	2.2	28.0	42.0	58.0
Stored at room temperature.	32	4	......	......	......	......	......	......	......	......	......	......
Stored at 33° F	32	4	......	......	......	......	......	......	......	......	......	......
LOT 2:												
Packed and processed	0	8	54.78	18.97	37.5	26.2	11.3	......	......	......	69.9	30.1
Stored at room temperature.	3	8	55.30	16.06	46.9	......	......	......	......	......	......	......
Do	15	8	52.00	22.16	63.7	31.3	32.4	1.9	2.2	27.6	49.1	50.9
Do	32	8	......	......	......	......	......	......	......	......	......	......
LOT 3:												
Packed and processed	0	25	52.57	21.85	37.7	27.1	10.6	......	......	......	71.8	28.2
Stored at room temperature.	3	25	56.84	16.95	49.6	......	......	......	......	......	......	......
Do	15	25	50.59	23.12	62.2	33.3	28.9	1.3	1.8	25.1	53.5	46.5
Do	32	25	......	......	......	......	......	......	......	......	......	......

[1] Surrounded with ice and salt mixture.

TABLE 33.—*Influence of time and temperature of storage on the formation of ammonia and amines in canned sardines*—Continued.

FISH EVISCERATED WHEN TAKEN FROM CAN—Continued.

Condition of fish.	Period held.	Period in dry salt.	Water.	Fat.	Volatile alkaline material as—							
					Nitrogen (N) per 100 grams.						Percentage of total.	
							Amines.					
					Total.	Ammonia.	Total.	Monamine.	Diamine.	Triamine.	Ammonia.	Total amines.
LOT 4:	*Mos.*	*Hrs.*	*P. ct.*	*P. ct.*	*Mg.*	*Mg.*	*Mg.*	*Mg.*	*Mg.*	*Mg.*	*P. ct.*	*P. ct.*
Packed and processed	0	[1]4	58.23	20.79	34.9	23.1	11.8	......	......	......	66.2	33.8
Stored at room temperature	2	4	65.00	12.65	43.2	......	......	......	......	......	......	......
Do	15	4	51.49	16.80	62.1	30.5	31.6	0.8	1.8	26.2	49.1	50.9
2 months at room temperature 13 months at 33° F	15	4	61.70	14.75	47.5	22.2	25.3	1.9	1.3	22.5	46.7	53.3
Stored at room temperature	32	4	......	......	......	......	......	......	......	......	......	......
Stored at 33° F	32	4	......	......	......	......	......	......	......	......	......	......
LOT 5 (FEEDY FISH):												
Packed and processed	0	6	56.94	18.07	35.7	23.6	12.1	......	......	......	66.1	33.9
Stored at room temperature	2	6	58.43	17.02	42.1	......	......	......	......	......	......	......
Do	15	6	56.48	19.03	62.9	31.4	31.5	1.1	2.2	27.9	50.0	50.0
2 months at room temperature 13 months at 33° F	15	6	53.88	22.37	40.5	19.6	20.9	1.5	1.1	18.2	48.4	51.6
Stored at room temperature	32	6	......	......	......	......	......	......	......	......	......	......
Stored at 33° F	32	6	......	......	......	......	......	......	......	......	......	......

VISCERA AND CONTENTS.

LOT 1:												
Packed and processed	0	4	56.78	20.01	39.9	26.2	13.7	......	......	......	65.7	34.3
Stored at room temperature	3	4	58.81	17.35	47.0	......	......	......	......	......	......	......
Do	15	4	56.44	19.15	66.4	32.8	33.6	2.2	3.4	28.7	49.4	50.6
3 months at room temperature 12 months at 33° F	15	4	54.15	23.20	52.4	22.3	30.1	1.3	2.5	26.9	42.6	57.4
Stored at room temperature	32	4	......	......	......	......	......	......	......	......	......	......
Stored at 33° F	32	4	......	......	......	......	......	......	......	......	......	......
LOT 2:												
Packed and processed	0	8	55.61	21.59	41.2	25.9	15.3	......	......	......	62.9	37.1
Stored at room temperature	3	8	56.10	20.41	45.6	......	......	......	......	......	......	......
Do	15	8	53.26	21.70	63.7	29.8	33.9	4.4	2.2	27.6	46.8	53.2
Do	32	8	......	......	......	......	......	......	......	......	......	......
LOT 3:												
Packed and processed	0	25	55.30	21.05	47.2	33.4	13.8	......	......	......	70.8	29.2
Stored at room temperature	3	25	55.56	20.65	51.6	......	......	......	......	......	......	......
Do	15	25	53.52	22.25	61.2	32.8	28.4	1.4	1.1	24.4	53.6	46.4
Do	32	25	......	......	......	......	......	......	......	......	......	......
LOT 4:												
Packed and processed	0	[1]4	61.47	18.54	36.6	25.0	11.7	......	......	......	68.3	31.7
Stored at room temperature	2	4	......	......	......	......	......	......	......	......	......	......
Do	15	4	......	......	......	......	......	......	......	......	......	......
2 months at room temperature 13 months at 33° F	15	4	53.78	21.40	49.1	21.3	27.8	2.1	2.9	22.5	43.4	56.6
Stored at room temperature	32	4	......	......	......	......	......	......	......	......	......	......
Stored at 33° F	32	4	......	......	......	......	......	......	......	......	......	......
LOT 5 (FEEDY FISH):												
Packed and processed	0	6	54.68	25.66	36.6	23.4	13.3	......	......	......	63.9	36.1
Stored at room temperature	2	6	54.02	26.84	40.5	......	......	......	......	......	......	......
Do	15	6	53.02	28.45	59.3	30.9	28.4	.6	9.2	16.7	52.1	47.9
2 months at room temperature 13 months at 33° F	15	6	49.39	31.98	44.8	21.9	22.9	......	......	......	48.9	51.1
Stored at room temperature	32	6	......	......	......	......	......	......	......	......	......	......
Stored at 33° F	32	6	......	......	......	......	......	......	......	......	......	......

[1] Surrounded with ice and salt mixture.

According to these results, variations in the preliminary treatment of the fish and their condition have no effect upon the formation of ammonia or amines during storage. Only slight variations are shown in the results of the analyses of the whole fish as removed from the can, the flesh alone, and the viscera and contents, indicating that no greater changes took place in any one portion than in the others. The quantity of total volatile alkaline material gradually increased during storage at ordinary temperatures in all three of the divisions made for analysis, but when stored at a temperature of 33° F. its formation was greatly retarded.

The relative quantities of ammonia and amines composing the total volatile alkaline material changed during storage. After processing practically two-thirds of the total alkaline nitrogen consisted of ammonia and one-third of amines. After storage these proportions changed, the volatile alkaline material consisting of about equal parts of ammonia and amines. Storage at a low temperature, while causing a decrease in the total quantity of ammonia and amines, apparently does not affect the relative amounts. The quantity of ammonia and amines in the storage samples is also about equally divided.

By far the largest part of the volatile alkaline material,[1] consisting of amines, existed in the form of triamine in canned sardines stored for the lengths of time used in these tests. Apparently the separations of the canned fish had no effect on the results for triamine. No uniform increase or decrease in the amounts of triamine contained in the different portions of the fish analyzed, due to the various periods or temperatures of storage, was shown. Monamine and diamine were present in very small amounts and about equal quantities at the end of 15 and 18 months. At the end of 32 months of storage no monamine was found, while the amount of diamine had increased in some instances, being double or more than double the quantities found at the end of 15 months. The temperature of storage apparently has no influence on the quantities of monamine and diamine formed.

CONCLUSIONS.

Marked changes in the quantities and relative amounts of ammonia and total amines took place in the canned fish on standing. In the case of packs composed of ground meat, these changes could be detected at one-month intervals, amounting in the first few months to an increase of approximately 5 mg of total amines per 100 grams of the material per month. Directly after processing the volatile alkaline material contained practically two-thirds ammonia and one-third amines. During storage at room temperature the proportions appeared to change slowly, until after a long period of standing the total alkaline material was about half ammonia and half amines.

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[1] As the method (37) for these determinations was not available at the time of the first examination of these packs, the data for the separation of the total amine fraction into its constituents are given for the longer periods of storage only.

When stored at a temperature just above freezing, the total quantity of volatile alkaline materials was greatly reduced, as compared with that produced at ordinary temperatures.

Sardines stored just above a freezing temperature for 32 months contained in most cases less volatile alkaline material than was found when they were held at room temperature for a period of 15 months. The relative amounts of ammonia and amines formed at the lower temperature of storage remain the same as the total volatile alkaline material formed while standing at room temperature. The total amines composing this volatile alkaline material consisted mostly of triamine (practically 80 per cent). Monamine and diamine also were present during the earlier period of storage (15 and 18 months), but in much smaller quantities. At the end of the 32-month storage period no monamine was found, but the diamine in some instances had increased 50 per cent or more. The difference in the rate of formation of ammonia and of amines at a lower temperature of storage and at room temperature suggests that these changes may be caused by bacterial growth, although it is more probable that this action is associated with detinning and adsorption of tin by the fish protein.

When the cans of long standing commercial packs were opened the fish constituting the 4- and 6-year-old goods were decidedly soft. These showed the presence of the largest amounts of amine.

The quantity of ammonia and amines in the canned sardines also has a decided bearing upon the detinning of the interior of the cans (p. 82).

It is planned to continue the studies on the relation of detinning to the formation of ammonia and amines in canned fish.

Effect of Freezing and Thawing on Sardines.

To determine the effect of freezing and thawing upon sardines, cans from each of the packs put up under the drying experiments (p. 51) were frozen and thawed, after which they were compared with cans of the same goods which had not been frozen. Three lots were employed. In one the sardines were frozen and thawed twice, in another three times, and in the third six times.

The general appearance of the oil sardines which had been frozen two, three, and six times was practically the same as that of the fish which had not been frozen. On closer examination, however, certain changes in the texture of the meat were readily recognizable. It was apparent that the texture of the fish which had been insufficiently dried was partially destroyed when frozen and thawed twice, the meat fibers being broken and the whole fish a trifle softer. These changes were more marked in fish from the same pack which had been frozen and thawed three and six times. After having received this treatment six times, the fish were quite soft, those which had been packed too "green" being difficult to remove from the can without breaking and tearing apart. The texture of the tissues of the fish which had been dried enough or too much changed very little after the pack had been frozen twice, but slight changes were detected in the same pack which had been frozen and thawed three and six times. In the case of the fish which lost an excessive amount of moisture during the drying process, the oil taking the place of water in the tissues served to protect them during the subsequent freezing and thawing.

In nearly all cases the flavor of the fish was slightly impaired by freezing and thawing. This was not always readily determined, for these packs were put up under conditions which did not allow the best flavor and taste to be conserved. In one pack which was not properly dried the soapy taste, so often present when fish are insufficiently dried, was very pronounced in all the cans opened. In a pack put up from excessively salted fish the lack of flavor was very pronounced, particularly when the fish had been dried so long that the oil flavor predominated.

The most marked changes caused by freezing and thawing took place in the mustard sardines. In nearly all cases, particularly when frozen six times, the mustard sauce lost its homogeneous appearance, and, where the fish had not been sufficiently dried, was partially decolorized. The change in the texture of the flesh was more pronounced than in the case of oil sardines, being apparent when frozen and thawed only twice. When frozen six times, the fish were soft, even mushy in some instances, and could not be taken from the can without breaking and tearing. The texture of the flesh was destroyed, the tissues becoming granular and friable. The loss of flavor was very pronounced, much more so than in the case of the oils. The fish from Castine Bay were dry, brittle, mealy, and practically tasteless, particularly when dried too long. These fish, when excessively salted and dried, were not quite as dry or as mealy after being frozen and thawed. Packed in mustard sauce, these fish were tasteless, dry, and brittle, while packed in oil they retained some of the fish flavor and were less dry and brittle.

In conclusion it may be said that freezing and thawing have no noticeable effect on the appearance of oil sardines. The change in the texture of the meat and the impairment of taste and flavor are slight when frozen and thawed twice, but more marked after they have been frozen and thawed a greater number of times. The damage resulting to oil sardines is directly proportional to the amount of water present in the fish and to the number of times the packed goods are frozen. Mustard sardines, however, are very seriously damaged by freezing and thawing, even once, particularly if improperly dried before packing. The texture of the flesh is destroyed, the appearance injured, and the taste lost.

The desirability of storing sardines at a low, even temperature was demonstrated by these experiments.

Detinning of Sardine Cans.

EFFECT OF SULPHUR IN SKIN OF FISH.

More or less blackening or detinning of the inner surface of the unlacquered sardine cans always occurs on standing. It was suggested by a former packer that this might be due to the action of some compound in the skin of the fish, as from his experience skinned fish when packed did not cause detinning. Sulphur was first considered as a possible cause of the detinning. A difference in the quantity of sulphur in the skin of the fish and in the flesh, provided the skinned fish did not attack the tin, would indicate that sulphur was an important factor in this phenomenon.

A small pack was made of skinned and unskinned fish from the same source which had been the same length of time in pickle. Part of the fish were skinned and then steamed, dried, and packed. The other portion was dried and packed without removing the skin. Both lots were packed in oil at the rate of less than ⅔ gallon per case, and were sterilized for 1¾ hours in a boiling water bath. In all respects, except for the skinning of part of the fish, the packs represented actual commercial conditions. Representative samples of the skin and flesh of the fish composing this pack were analyzed, with the results shown in Table 34.

Table 34.—*Composition of skin and flesh of sardines.*

Determination.	Skin.	Flesh.
	Per cent.	*Per cent.*
Water	63.60	70.76
Fat	14.62	3.56
Total nitrogen (N)	2.85	3.90
Protein (N×6.25)	17.81	24.38
Salt (NaCl)	4.05	1.79
Total sulphur (S)	0.207	0.260
Total sulphur (water and fat free basis)	0.95	1.01
Total sulphur (water, fat, and salt free basis)	1.17	1.09

The amount of sulphur in the skin was practically the same as that in the flesh of these fish. A marked difference in the extent of detinning between cans packed with the skinned and those packed with the unskinned fish would not, then, be due to the quantity of sulphur present, although it might be due to its form of combination. No work, however, was done to determine the form in which sulphur exists in the skin or flesh of the fish. Different combinations of sulphur, in the form of cystein, cystin, and keratin, are found in animal tissues. The first two occur in the true proteins or meat tissues, while the last is the principal sulphur-bearing constituent of hair, nails, skin, etc. Theoretically, if sulphur has any relation to detinning, that in skin should exert the least effect. To a certain extent this is confirmed by the results of the experiments.

The examination of a few cans from these packs three months after they had been processed showed that portions of the surface of the cans containing the unskinned fish had become blackened or detinned, usually where the skin of the fish came in contact with the can. In rolling the lid back or in taking the fish from the can pieces of skin adhered to the lid or bottom of the can. The surface immediately below this was detinned and sometimes slightly pitted, while the surface of the can not in contact with the fish remained bright. The interior surface of the cans containing the skinned fish showed black markings on both the lid and bottom, in some instances a little more marked than in the cans of the unskinned pack. In the pack of skinned fish the entire surface of the can, although not black, was tarnished or dulled. The detinning appeared to be more general over the whole surface, that is, there were no bright places on the surface, as was the case in the pack of unskinned fish. It was quite evident that more corrosion of the surface of the can occurred in the pack of skinned fish than in the pack of the unskinned fish.

After standing six months, the same markings in the interior of the cans, perhaps a little more pronounced, were found in the cans of unskinned fish. Several places where the fish had come in contact with the surface of the cans were detinned and slightly pitted. The portions of the cans not touched by the fish remained bright and untarnished. All the cans examined were attacked to about the same extent. The skin that adhered to the cans was carefully removed and added to the sample for analysis. Besides being tarnished, the surface of the cans containing the skinned fish was badly pitted, and small pieces of the fish adhered to the cans at the end of six months. This pitting and adherence of the flesh to the surface of the can had not taken place after three months' standing.

After six months' standing the interior surface of the cans containing the skinned fish had been attacked to a greater extent than had the surface of those in which the unskinned fish were packed. In both cases more corrosion was shown after six months' standing than after three months' standing, and in both instances it was more marked in the case of the unskinned fish.

The water, oil, and tin contents of samples of these two packs are shown in Table 35.

TABLE 35.—*Composition of sardines (skinned and unskinned) stored in cans for 3 and 6 months.*

Period held.	Water.	Oil.	Tin.[1]
Unskinned fish:	*Per cent.*	*Per cent.*	*Mg. per kilo.*
3 months	52.19	18.88	194
Do	52.67	15.64	[2] 66
6 months	55.00	16.20	172
Skinned fish:			
3 months	56.00	14.93	225
Do	56.81	14.89	85
6 months	54.68	19.31	145
Do	56.13	17.81	[3] 319

[1] Determinations made by E. L. P. Treuthardt, Food Control Laboratory, Bureau of Chemistry.
[2] Least detinning in any of cans examined.
[3] Worst of lot, tarnished all over and one-half surface pitted.

The tin removed from the can varied greatly among the individual cans, but in some cases corresponded to the amount of tarnishing or detinning undergone by the can. The tin content of the pack of skinned fish was, on an average, higher than that of the pack of unskinned fish. It was observed, incidentally, that detinning is reduced to a minimum when the cans are well filled with oil, and progresses more rapidly in cans where too little oil has been added or where the fish have absorbed the oil, thus removing the protective film between the fish and the can. The examination of these packs showed that the corrosion of the interior of the can was progressive and was more extensive in the packs composed of skinned fish.

Apparently sulphur is equally distributed through the flesh and skin of the fish and is not primarily responsible for the corrosive action of the contents of the can. The blackening of the areas detinned and the excrescences sometimes seen are due to the formation of iron sulphid. This probably is the extent to which sulphur enters into the reaction in the corrosion of the tinned plate.

EFFECT OF AMMONIA AND AMINES.

That the alkaline materials, ammonia and amines, are primarily the cause of part, at least, of the detinning which occurs in sardine cans was shown by the following experiments.

Ammonia and amines, found in appreciable quantities in commercial and experimental packs of sardines, increase during storage (p. 70). That amines have a corrosive action on tin plate when confined in cans has been shown by experiments[1] in which monomethylamine of various strengths was sealed in cans and allowed to remain for different periods of time. Bigelow and Bacon(3) attributed the corrosion of the interior of tin containers used for canning shrimp to monomethylamine. A. Rössing(24) found the interior of cans in which sterilized lobsters and codfish had been preserved for several years to be covered with a white coating composed of stannic oxid, phosphoric acid, and iron. He attributed the corrosion to the action of phosphate and ammonia contained in the codfish and lobster.

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[1] Unpublished results on file in the Bureau of Chemistry.

Determinations of the total amount of tin in packs of sardines in mustard sauce and of the tin content of mustard sauce, plain and fortified with acetic acid, when packed separately, showed that more tin was present in the fish and the sauce than in the sauce alone.[1] This observation is in agreement with the conclusions drawn by Goss(10) who stated that the tin which is dissolved from the can forms an insoluble compound (by adsorption) with the protein and carbohydrate (starch) elements of food. The active materials, acids or alkaline substances, responsible for the solution of the tin are then left free to dissolve more tin. This action may go on until no more tin can be taken out of solution by the food products within the can, or until detinning is complete.

It having been shown that diamine and monoamine are associated with ammonia and triamine, as constituents of the total volatile alkaline material formed in sardines (p. 75), solutions of all these amines were used to determine the extent of corrosion when present in sardine cans. The amine solutions, in approximately twentieth normal strength, prepared from Kahlbaum's highest purity 33 per cent solutions, were introduced into the ordinary quarter oil cans. The interior of the cans and the lids were thoroughly cleaned by washing with alcohol and ether. The lids were then soldered on and the solutions introduced by means of a pipette through a tap and a vent hole in the end of the cans. As soon as the cans were filled, these holes were closed by a drop of solder. The cans were next processed for one hour in boiling water. One set was opened immediately after cooling and the others placed aside for future examination. The results of the determination of tin in the solutions after being removed from the cans, and the extent to which the inner surfaces of the cans were corroded are given in Table 36.

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[1] Unpublished results on file in the Bureau of Chemistry.

TABLE 36.—*Detinning action of weak solutions of ammonia and amines (alkylamines).*

Solution employed.	Weight of solution in can.	Titration of 10 cc of solution.		Total tin in solution.	Color and odor of solution.	Corrosion of can.
		Before canning.	After canning.			
	Grams.	*Cc N/20* H_2SO_4. (1)	*Cc N/20* H_2SO_4. (1)	*Mg.*		
Opened directly after processing:						
Distilled water	88.1			0.0	Very slight yellowish tinge	Bright on opening; tarnished on exposure to air (rust). Apparently no corrosion of tin coating.
Ammonia	109.3	9.9	9.7	2.99	Ammoniacal odor; very slight yellow tinge.	Badly mottled. Corrosion of tin noticeable. Tin coating of plate dull in color. Worst attacked of lot.
Trimethylamine	115.5	9.6	9.5	3.55	Strong ammoniacal odor; slight yellow tinge.	Mottled. Interior of can, particularly cover, apparently rusted.
Dimethylamine	120.6	9.9	9.85	4.65	Slight ammoniacal odor; faint yellow tinge.	Very slightly mottled. Interior bright. No tarnish. Excluding can with water, appeared to be least attacked.
Monomethylamine	124.2	9.9	9.7	7.33	Very slight ammoniacal and aromatic odor; yellowish color.	Somewhat mottled. No tarnish; coating bright.
Equal parts ammonia and trimethylamine.	118.9	9.75	9.5	2.92	Slight ammoniacal odor; faint yellow tinge.	Badly mottled. Tin coating attacked, slightly dulled. Second in extent of corrosion.
Opened after standing 3 months:						
Ammonia	97.7	9.4	9.1	13.31	Strong ammoniacal odor on opening can; disappeared on standing; slight yellow tinge.	Noticeably mottled. Faintly tarnished. Corrosion and attacking of plate apparent at one portion of can, but interior on the whole bright.
Trimethylamine	99.4	9.4	8.6	10.24	Strong ammoniacal odor; slight yellow tinge.	Interior of can bright; scarcely mottled. Least attacked of any of cans.
Dimethylamine	70.5	10.0	9.2	58.98	Ammoniacal odor; slightly cloudy; marked yellow color.	Worst attacked can of lot. Badly tarnished and mottled. Badly corroded in places. Not as full of liquid as others. Line of corrosion at top of liquid could be determined on inside of can. Cover as badly attacked as bottom of can.
Monomethylamine	99.5	10.6	10.3	14.51	Slight ammoniacal odor; faintly cloudy; no color.	Practically no tarnish. Surface bright, but mottled.
Equal parts ammonia and trimethylamine.	87.5	9.4	8.9	17.42	Strong ammoniacal odor; yellow color; faintly cloudy.	Slightly tarnished. Interior of can dull and mottled.
Opened after standing 8 months:						
Ammonia	95.6	9.4	9.6	12.92	Ammoniacal odor; slight yellow color.	Mottled. Not badly tarnished nor deeply attacked.
Trimethylamine	99.1	9.4	9.3	7.72	Slight amount gas; slight ammoniacal odor; slight yellow tinge.	Slightly mottled. Least attacked in appearance of any of cans of this lot.
Dimethylamine	99.3	10.0	9.9	8.51	Slight amount gas; slight ammoniacal odor; slight yellow tinge.	Mottled. Little tarnished. Third in point of degree of corrosion.
Equal parts ammonia and trimethylamine.	86.1	9.4	9.4	11.27	Ammoniacal odor; slight yellow tinge.	Mottled. Not badly tarnished.

[1] Neutral.

On standing, a small amount of a white sediment containing 0.4 to 0.9 mg of tin settled out from the solutions when the contents of the cans were transferred to digestion flasks. This was undoubtedly an oxid of tin.

Of the cans opened directly after processing, those containing distilled water were not attacked. The cans containing ammonia appeared to be attacked the most. Next, in order of the apparent degree of corrosion, was the can containing equal parts of ammonia and trimethylamine, followed in order by those containing trimethylamine, monomethylamine, and dimethylamine. The apparent extent of corrosion in this series does not conform to the actual amount of tin removed. The can containing monomethylamine lost the most tin, while the least went into solution in the mixture of ammonia and trimethylamine.

In the lot which stood for three months, the cans containing dimethylamine showed the greatest effect, as well as the removal of the largest amount of tin. The fact that these cans were only partly filled may account for the greater corrosive action. Next in amount of corrosion came the cans containing ammonia and trimethylamine, with monomethylamine third. In this group the apparent extent of corrosion agrees fairly well with the actual amounts of tin determined.

Of the cans which stood for eight months, those containing ammonia and equal parts of ammonia and trimethylamine were attacked the most. Dimethylamine followed in order of severity, while the ones containing trimethylamine appeared to be the least attacked. The amount of tin in solution agreed with the observations made on this lot. Unfortunately no monomethylamine was available for comparison at this period.

The variation in the amount of tin found in these solutions at different periods may be due to variations in the quality of the tin plate of the cans. No attempt was made to obtain cans composed of the same plate, the cans used being taken from a miscellaneous lot.

These results, although limited in the number of cans tested, show that weak solutions of ammonia and amines exert a detinning action on the interior of the cans, and that this action increases on standing up to a period of at least three months.

Conclusions.

Ammonia and amines are formed in sardines stored for any length of time, the amount depending upon the period and temperature of storage. Sardines held at room temperature contain a higher percentage of ammonia and amines than when they are held just above freezing. Ammonia and amines in solution are believed to be responsible for a great part at least of the detinning which occurs in sardine cans.

The damage done to oil sardines by freezing and thawing is negligible in comparison with that done to mustard sardines.

The results of these experiments show that it is most desirable to store sardines at a low, even temperature.

DECOMPOSITION OF THE FISH.

The flesh of fish differs in composition from that of animals in that it is relatively richer in gelatin-yielding material (collagen) and contains a smaller proportion of extractives. It is probable that certain bacteria grow more rapidly on fish than on meat, thus explaining the greater rapidity in the decomposition of fish. The end products of decomposition of the flesh of fish are the alkaline substances, ammonia and amines. Fish flesh contains a small amount of ammonia as a normal constituent, and the tissue juices doubtless contain amines, but in such small quantities that their presence in appreciable amounts may be considered as an evidence of decomposition. This is true also of the flesh of the lobster, crab, and shrimp, to which group of marine life the organisms classed as feed for the sea herring belong.

Indices of Decomposition.

AMMONIA AND AMINES.

During the course of this investigation a number of determinations of the amount of ammonia and amines present in fresh fish and in fish at various stages of spoilage were made. Fish free from feed and fish containing feed in different stages of digestion, some of them belly blown, were examined. The average of numerous determinations showed that the fresh fish contained from 1.5 to 2 mg of ammonia and amines, as nitrogen per 100 grams of fish, or, calculated to the water and fat free basis, 11 to 12.5 mg per 100 grams of fish.

The transportation experiments (p. 26) brought out the following facts: In the case of small fish which contained no feed, and were kept, without the addition of salt, at 54° C., the viscera and contents decomposed more rapidly than did the flesh. In the case of larger fish, containing a little feed and transported without salt, the ammonia and amines in the viscera and contents increased from 12.6 mg in the fresh material to 22.3 mg per 100 grams of material at the end of 12 hours, while that in the flesh increased only from 13 to 14.5 mg during the same period. After these fish had stood for 24 hours, the flesh showed a decided change, with evidence of marked decomposition. In the case of fish carried in salt (1½ sacks per hogshead), a noticeable increase in ammoniacal material, from 11 to 18.2 mg per 100 grams, had occurred in the viscera and contents by the end of the 4-hour period of holding.

Fresh fish containing some feed, but hardly to be classed as feedy, after standing for certain periods of time, showed a marked increase in the ammonia and amines in the viscera and contents, as a result of decomposition. The 11.6 mg of ammonia nitrogen per 100 grams of fish in the stomach and intestinal contents increased on standing for 6 hours to 16.3 mg, and on standing for 20 hours to 21 mg over the amount found in the fresh fish.

In still another experiment, the viscera and contents of the fresh fish contained 12.6 mg of ammoniacal material as nitrogen per 100 grams of the sample when fresh, 14 at the end of 4 hours of standing, 15 after 6 hours, 17.7 after 8 hours, and 22.3 after 12 hours.

A preliminary experiment to determine the amount of ammonia and amines formed when fish decompose showed that the greater part of these alkaline bases formed during decomposition pass into the solution when the spoiled fish are placed in pickle. These results, coupled with the condition, approximating that of salt fish, when fish for sardines are held too long in pickle or in dry salt, indicate that a transfusion of material from sound fish into the brine or pickle occurs.

Experiments were conducted to ascertain the amount of decomposition which occurs in the viscera and contents of fish kept in pickle for various periods of time. The data thus obtained are given in Table 37.

TABLE 37.—*Decomposition in viscera and contents of fish kept in pickle.*

In pickle.	Before packing (raw viscera).				After packing and processing.			
	Water.	Fat.	Salt.	Total volatile alkaline material (ammonia and amines) per 100 grams.	Water.	Fat.	Salt.	Total volatile alkaline material (ammonia and amines) per 100 grams.
Hours.	*Per cent.*	*Per cent.*	*Per cent.*	*Mg.*	*Per cent.*	*Per cent.*	*Per cent.*	*Mg.*
Lot 1:								
0	56.58	32.00	0.42	15.2	58.61	19.77	0.49	40.8
6	56.70	26.62	2.46?	16.3	43.31	28.46	3.91	46.6
12	54.40	25.96	4.53	19.8	45.76	28.16	8.69	43.7
24	57.47	27.12	4.22	28.0	47.96	27.32	4.21	42.7
Lot 2:[1]								
0	50.93	38.08	.29	13.4	56.70	23.89	.23	35.6
6	51.06	37.24	1.71	18.3	53.62	26.58	1.56	39.0
12	49.53	35.08	2.93	38.4	50.40	26.62	3.32	47.8
24	51.62	32.30	3.55	36.1	44.92	30.87	3.87	45.4

[1] Slightly feedy.

The decomposition of the raw viscera increased markedly in both lots of fish during the time they were held in pickle, lot 2, made up from slightly feedy fish, showing the greater increase. The amount of volatile alkaline material increased markedly in both lots after processing. The increase due to processing was sufficient in the case of lot 1 to mask that due to the decomposition found at any stage. Decomposition is indicated in the processed material in the case of the slightly feedy lot.

The amount of ammoniacal material thus far reported in this section includes both ammonia and amines. The following data show the production of amines during the course of decomposition of the flesh and the viscera and contents of fish.

The flesh of eviscerated fresh fish showed the presence of 0.53 mg of amines, in terms of nitrogen per 100 grams of sample. After a portion of this lot of fish had stood for 24 hours with the viscera intact, samples were prepared by eviscerating the spoiled fish. The content of amines had risen in the flesh to 14.53 mg per 100 grams. These fish had no pronounced odor, but the bellies of the greater part were ruptured, and they were spoiled to such an extent as to be unfit for packing.

The viscera from several lots of fresh fish, which contained feed in the intestines in a state of practically complete digestion, showed a maximum of 1.60 mg and a minimum of 1.31 mg of amines, expressed as nitrogen per 100 grams of sample.

The viscera of fish, the stomach portions of which were full of shrimp, contained a maximum of 16.07 mg and a minimum of 12.99 mg of amines, as nitrogen per 100 grams of sample. Some of the fish from which the viscera were obtained were badly belly blown, while others showed only the preliminary softening and a slight rupturing of the belly tissues.

In the special investigation conducted during the fall of 1916, the total volatile alkaline nitrogen determined in the feed taken from belly-blown fish on arrival at a cannery amounted to 37.7 mg per 100 grams of sample. Of this quantity 20.6 mg were amine nitrogen, and 17.1 mg ammonia nitrogen.

Portions of the samples of the feed itself, collected from the waters in the vicinity of the fishing grounds, were allowed to decompose under the most favorable conditions, at incubation temperatures, and samples were taken at different periods. Ammonia and amines in very large quantities were found in all cases as products of the decomposition.

The examination of the stomach and intestinal contents of a number of fish which had been out of the water different lengths of time showed that raw fish whose stomachs were full of undigested shrimp gave from 10 to 15 times the quantity of amines found in the viscera from fish which contained material in a more advanced stage of digestion.

VOLATILE SULPHUR.

The amount of volatile sulphur in the viscera of fish which contained feed was determined, and the results, expressed in terms of cubic centimeters of N/100 iodin solution reduced per 100 grams of material, were compared with those obtained on fish containing practically no feed. In the viscera of fish containing no feed a reduction of 4.5 cc of iodin solution was obtained, against a reduction of 12.6 cc from the viscera of fish which were somewhat feedy.

Experimental Packs from Decomposed Fish.

Even in the presence of salt or pickle decomposition proceeds in the viscera of the fish, particularly when a large amount of feed is present. This fact is borne out by the experience of the fishermen and boatmen, who report that when feed is abundant, no amount of salting or any known way of treating the fish will keep them from spoiling. Decomposition begins and rapidly extends in the viscera and contents long before it is manifest in the flesh of the fish. When free from the viscera and contents (eviscerated), the fish, at the temperatures prevailing in this region, do not show evidence of decomposition for a fairly long period of time.

A series of experiments were conducted to ascertain the amount of decomposition in sardines packed under varying conditions of spoilage. Fish which would pack 6 to the can, from a lot taken without salt or pickle directly from the weir to the wharf, were flaked after they had been out of the water for three hours, and at once analyzed, to determine the water and fat content, the ammonia and amines, and the acidity of the fat.

About 1¾ buckets of these fish were placed in a barrel containing 1½ buckets of pickle, the amount usually employed for this quantity of fish. Because of a temporary lack of water at the factory where the experiment was conducted, a pickle prepared the night before, and previously used to hold 2 bushels of fish for 2 hours, was used. It registered 100° on the salimeter, however, and was but slightly colored. At intervals of 30 minutes, 1 hour, 1½ hours, and 2 hours portions of the fish were removed from the pickle, flaked, and samples analyzed. The rest of the fish were allowed to stand for 24 hours in a basket in the pickling shed, where the temperature was about 60° F. At the end of this time the same procedure was followed for the 24-hour-old fish. The results of the analyses of these fish are given in Table 38.

Although ammonia and amines were extracted from the fish by pickle, a sufficient quantity remained, at the various periods of time given, in the 24-hour-old fish to indicate an appreciable decomposition. The results obtained for the acidity of the fat suggest that this determination may also have value as a measure of decomposition. The evidence of decomposition in the fish after standing for a period of 24 hours without salt or pickle was very marked.

TABLE 38.—*Composition of fresh and 24-hour-old fish before and after being in pickle from 30 minutes to 2 hours.*

Condition of fish.	Water.	Fat.	Total volatile nitrogen per 100 grams as ammonia and amines.	Moisture and fat free basis.		Acidity of fat as N/20 sodium ethylate per gram.
				Total volatile nitrogen per 100 grams as ammonia and amines.	Amino acid nitrogen.	
Fresh fish from weir:	*Per cent.*	*Per cent.*	*Mg.*	*Mg.*	*Mg.*	*Cc.*
3 hours out of water, no pickle or salt	69.00	8.44	21.0	93.1	2.50	7.0
In pickle—						
30 minutes	67.84	7.57	21.0	85.4		
1 hour	67.52	8.47	18.6	77.5		
1½ hours	67.46	8.63	18.6	77.8		
2 hours	67.38	6.62	18.6	71.5	2.50	9.09
Same lot 24 hours old:						
After standing 24 hours, no pickle or salt	71.36	6.56	46.6	211.0	2.40	8.96
In pickle—						
30 minutes	68.24	8.28	37.3	169.9		
1 hour	69.65	5.43	35.0	140.4		
1½ hours	69.40	5.42	32.6	129.5		
2 hours	66.99	6.84	28.0	107.0	1.96	9.20

Packs of the fresh, 12-hour-old, and 24-hour-old fish were made in oil and without oil, as well as from each lot held for different lengths of time in pickle. In each pack the fish were steamed for 12 minutes, dried for three-quarters of an hour in a tunnel drier, and then packed in ordinary one-quarter cans. Oil was added to part of the pack; the rest of the cans were left dry. The cans were processed at the temperature of boiling water for 2½ hours. The fresh fish packed easily and quickly, and made a very good looking pack. At the time of packing about half of the 12-hour-old fish and nearly all of the 24-hour-old fish were belly-broken and soft.

The results of these analyses, made as soon as the sardines were allowed to cool after processing, are given in duplicate on samples of fish packed in oil from the fresh lot, and after 2 hours in pickle, and from the 24-hour-old fish, before and after they had been 2 hours in pickle (Table 39).

The evidence of decomposition was quite marked in the goods packed from the 24-hour-old fish which had not been in pickle. Holding both the fresh fish and the 24-hour-old fish in pickle for 2 hours decreased the amount of ammonia and amines in the packs made from them. The packs made from fish which stood 24 hours showed a greater loss in alkaline material than those made from the fresh fish. The acidity of the fat of the fish packed in oil and processed increased slightly during spoilage and during the periods in pickle.

TABLE 39.—*Composition of fish packed fresh and at the end of 24 hours.*

Condition of fish.	Water.	Fat.	Total volatile nitrogen per 100 grams as ammonia and amines.			Acidity of fat as N/20 sodium ethylate per gram.	
			Original basis.	Moisture and fat free basis.			
				Total.	Average.	Total.	Average.
	Per cent.	*Per cent.*	*Mg.*	*Mg.*	*Mg.*	*Cc.*	*Cc.*
Fresh, no pickle or salt, packed in oil, and processed [1]	57.00	18.90	35.0	145.2	147.6	1.74	1.70
Do	54.12	24.13	32.6	149.9		1.65	
Fresh, 2 hours in pickle, packed in oil, and processed [1]	50.41	26.00	30.3	128.4	133.1	1.70	1.63
Do	54.00	22.35	32.6	137.8		1.55	
24 hours old, no pickle or salt, packed in oil, and processed [2]	50.06	23.48	49.0	185.2	189.6	1.90	1.83
Do	54.53	21.45	46.6	194.0		1.75	
24 hours old, 2 hours in pickle, packed in oil, and processed	47.76	25.23	39.6	146.6	154.9	2.20	2.04
Do	51.73	21.14	44.3	163.3		1.88	

[1] Same as first lot of fish given in Table 38.

[2] Same as second lot of fish given in Table 38.

Table 40 shows the results of the determination of the ammonia and amine in packs of the same fish in oil and without oil, as well as those from this same lot allowed to stand for 12 hours before being placed in pickle. The sardines on which these analyses were made stood for about 7 months under conditions of storage which would approximate those found in actual practice. The analyses were made in triplicate, but only the average results of the determination of ammonia and amines calculated to a moisture and fat free basis are tabulated. Total nitrogen was also determined on these packs, but the results showed no variation that would indicate a loss of protein material under the conditions of the experiment, for which reason they are not included in Table 40.

The cooking received during sterilizing very greatly increased the amount of ammoniacal material in the packed fish. In the case of the fresh fish, not in pickle, this increase amounted to 54.5 mg per 100 grams immediately after processing, and to practically 117 mg per 100 grams after the sardines had stood seven months. Not enough ammoniacal substances were extracted from the fresh fish during the time in pickle to cause a very noticeable decrease in the ammonia and amine content of these same fish after they had been packed and sterilized. The ammonia and amine content, however, had a tendency to decrease with the length of time the fish remained in pickle. This was more markedly shown in the case of the fish packed without oil. The ammoniacal nitrogen content was greater in the pack of fish from the 24-hour-old lot, not in pickle, than in the pack from the fresh fish without pickle. The quantity of ammoniacal material found in this pack (24-hour-old fish) decreased according to the length of time in pickle. In general, the results of the analyses of the different lots of fish packed without oil agreed very well with the results on the packs in oil, about the same quantity of ammonia being found in both cases. These results show that canned sardines contain more ammoniacal material than the fresh fish.

TABLE 40.—*Total volatile nitrogen (ammonia and amines) on water and fat free basis in packs with and without oil.*[1]

Condition of fish.	Total volatile nitrogen (ammonia and amines) on water and fat free basis per 100 grams.	
	Packed in oil.	Packed without oil.
	Mg.	*Mg.*
Fresh (3 hours out of water):[2]		
Not in pickle	210.2	205.2
In pickle—		
30 minutes	203.1	220.7
1 hour	206.1	193.0
1½ hours	204.5	224.1
2 hours	202.8	191.3
12 hours old:		
Not in pickle	204.0	207.0
In pickle—		
30 minutes	204.2	194.0
1 hour	188.8	173.0
1½ hours	179.9	217.3
2 hours	204.2	199.6
24 hours old:[2]		
Not in pickle	227.2	221.0
In pickle—		
30 minutes	209.8	206.3
1 hour	205.4	201.0
1½ hours	196.8	189.3
2 hours	183.6	177.0

[1] These sardines had been packed about 7 months.

[2] Same as lot of fish given in Table 38.

In the case of fish which had undergone an excessive decomposition the results point to the possibility of detecting this degree of spoilage in the packed goods. The length of time in pickle had a more marked influence on the ammonia content when the fish were in an advanced stage of decomposition than when they were fresh.

The determination of volatile alkaline material, expressed in terms of ammonia and amines, in the canned product, therefore, becomes of doubtful value as a means for detecting decomposition of a less degree in fish which have been in salt or pickle.

The process of pickling and salting the fish is subject to extreme variations. There is no uniformity in the length of time the fish remain in pickle, in the degree of salinity of the pickle, in the amount of salt used in dry salting, in pumping off the brine formed when the fish are dry salted, or in the length of time of processing, all of which have a marked effect upon the ammonia and amine content of canned fish. In consideration of these factors it would be impossible to gage the extent of decomposition undergone by the commercial canned product from the ammoniacal substances alone. Furthermore, processing produces a quantity of ammonia and amines greatly in excess of that found normally and sufficient to mask the quantities of these substances formed during the actual spoilage of the fish in the raw state.

GRADING THE FISH.

As already stated, the fish received at the cannery vary in quality according to the season of the year and to the treatment to which they have been subjected during transportation. Obviously best results can not be obtained unless some differentiation is made in the treatment of these fish during the packing process. This investigation showed that all the fish, fat or lean, excessively salted or pickled or the reverse, were sent through the cannery together. In a majority of the canneries the fish were not sorted according to size. At one plant the best lot of oil-size fish received during the season were mixed with very inferior fish that had been in pickle over night and were soft and, in many cases, belly broken. These dull, leached-out fish should have been discarded at once, instead of which they were packed in cans with the good fish, to the detriment of the entire output from that particular cannery. It is a great economic waste for the sardine canner to adopt a routine method for treating every lot of fish brought in. Best results can be obtained only when the fish are separated at the cannery into different grades with respect to quality. Greater care should be used in handling fish of poorer quality, thus insuring better results in the finished product. The various grades should be kept together throughout the process.

FEEDY FISH.

Packing badly belly-blown fish has done more than any other one factor to bring the Maine sardine into disrepute. Excessively feedy fish should not be taken from the water (p. 18), and fish which reach the cannery in a badly belly-blown condition should be discarded (Pl. XIX). The packing of fish containing feed should not be permitted under the present methods of snipping and shearing. Small pieces from the gills and particles of partially digested food from the stomachs produce a messy appearance on the surface of the packed fish.

A reasonable limit for the amount of feed fish may contain before being rendered unfit for packing should be established. In determining such a standard, the method and time of transportation, the extent of the rupture of the belly portion of the fish, the grade of sardines into which they are to be packed, whether they are to be cut or cut and eviscerated before canning, and other factors should be taken into consideration.

SMALL FISH (BRITT).

The facilities for handling the fish and the processes employed at the present time are not at all suited for "britt," as fish from 1½ to 2½ inches are called. With the methods now in vogue a good article can not be prepared from britt. In the first place, they are taken in entirely too large quantities, 50 or 60 hogsheads of fish about 2½ inches long being actually landed at a cannery in one load. In most of the canneries they are treated in exactly the same manner as the larger fish. The waste is enormous, and the taking of these fish, which would, in from two to three months, be of sufficient size to make easy handling and packing, constitutes a great economic loss. When the catch is composed of large and small fish, even if completely separated at the cannery by running them through a separator, the loss is too great to make a sacrifice of these small fish in the quantities sometimes taken. If the larger fish are not separated from the britt, as is the case in the majority of the canneries, the small fish are not discarded until they reach the packing tables. Since, as a general thing, they can not be flaked properly, they fill up the spaces between the larger fish, delay drying, and increase the damage and marring of the larger fish when they are separated during packing.

Small fish from 1½ to 2½ inches long should not be taken from the water. Legislation should be enacted prohibiting the taking of fish of this size. In the case of a mixed run, regulations should be prescribed as to the percentage of these small fish which may be taken in a catch. No attempt should be made to pack fish that are less than 3 inches long, and this size should be accepted only when the packers are willing to take them in small quantities and devote sufficient time and attention to their preparation to insure a first-class article.

MARRED OR BROKEN FAT FISH.

The methods developed in packing Maine sardines, for example, the steaming and drying process, and others that are utilized in transportation and packing the fish, at the speed and in the quantities handled, are not suited to the physical structure of the more delicate and tender fat fish, which will not stand rough treatment without being marred and broken. Their use is not conducive to speed in packing, with resulting quantity, which is desired in the preparation of the cheaper grade of sardines. For these reasons preference has been given to the thinner and firmer fish for use in this class of goods. These fish, deficient in fat, are taken during the early part of the season, particularly during the spring catch or during a scarcity of feed. While it is generally conceded that sardines made from fat fish are superior in flavor to those made from the thinner fish, they are not in general favor among the packers because of the difficulties in handling them. The tissues of the fat fish are exceedingly tender, so that they are easily marred and broken; consequently great care must be exercised to obtain a neat looking can.

To rule that all broken fat fish should be discarded would result in a great waste of good, wholesome food material. Some means should be provided for using the broken and marred fat fish, other than mixing them with, and spoiling the appearance of, packs made from undamaged fish. These fish should not be mixed with the undamaged fish, but may be utilized legitimately by packing them as mustard sardines or "backs up" in oil, with the understanding that this method of packing designates seconds or broken and marred fish.

In packing the better or fancy grade of sardines unbroken fat fish of superior quality are to be preferred. It would be desirable to select the better quality of fish, whenever they can be obtained, for packing the fancy grade of sardines and use the poorer quality of fish in the cheaper sardines.

The Norwegian sardine packers recognize the value of fish of good quality, and pack the better grades of sardines at a season when the fish are the fattest, and consequently of the best value.

CUTTING AND EVISCERATING THE FISH.

All fish used in the preparation of sardines should be cut and eviscerated. Under present conditions it would be impossible to cut all the fish. The employees are decidedly averse to hand cutting, and it would be impossible to secure a sufficient force to cut all the fish during a heavy run. Several of the canneries, however, have succeeded with hand labor in cutting fish of a certain size, while a few cut most of the large fish used for mustard sardines. Since this investigation was undertaken much progress has been made in the development of mechanical devices for doing this work. Several canneries now use mechanical means for beheading the fish. It is hoped that eventually all fish will be cut and eviscerated by machinery.

It is most desirable that fish be eviscerated as well as beheaded before starting them through the canning process. Experiments have shown that the viscera and contents are responsible for the early and rapid spoiling of the fish. Not only does cutting and eviscerating prevent such decomposition, but it also facilitates matters all along the line in the packing of sardines. It will abolish the practice of "snipping" and "shearing" the fish during packing and will practically eliminate the handling of the large amount of refuse in the packing room. It shortens the length of time in pickle after the fish reach the cannery, thus eliminating the damage and loss resulting when fish are held too long in salt and pickle. It reduces to a negligible degree the chemical changes which fish undergo in brine or pickle, causing the removal of a large part of the material which is characteristic of fresh fish and which is so largely responsible for the delicate flavor. It greatly reduces the time required for drying, and finally an important reason for cutting and eviscerating the fish is that if generally adopted it will aid materially in solving the "feedy" problem, by the removal of the feed and viscera before an advanced stage of decomposition, brought about by the bacteria associated with the feed, has been reached.

STANDARDIZATION OF THE SARDINE PACK.

In order to satisfactorily market any commodity it is essential that standards should be established before sales are made. It is then the duty of the manufacturer to see that his product complies with the standard adopted. At present there are no uniform grades or standards for sardines upon which a satisfactory marketing and selling arrangement could be based. Although several canners have standardized their pack and sell their goods on a basis of quality, the great majority have in the past sold their products simply as sardines, without reference to their merit. As a result the jobbing trade does not look for a definite uniform quality in Maine sardines, but governs its purchases by price alone. Such a condition nullifies the attempt of those packers who have made an effort to standardize their packs, and often forces them to cast a high-grade article in with the poorer grades of those who care less for quality than for quantity.

The greater part of the Maine pack is sold under the distinctive name "standards." They may be very good, or they may be inferior, and often their quality is unknown to the packer. The jobbing trade has become so accustomed to this class of goods that quality is not a consideration in the transaction.

Probably in no other line of goods does this lack of systematized dealing between producer and distributor work more hardship on the consumer. Price and the nature of the competition caused thereby rule the quality of goods produced, with the result that the whole tendency on the scale of quality is downward.

PROPOSED SPECIFICATIONS.

The following specifications, based on the division of the pack into four subdivisions, is offered as a working basis for a standardization of the pack of Maine sardines.

Standards.

Cans.—Quarter size only, plain or decorated.

Fish.—Not less than 5 to a can, preferably 6. Steamed; not necessarily eviscerated, though this would insure a better product; carefully packed brights up, to make a neat and attractive package.

Oil.—Prime, summer yellow cottonseed, or corn, not less than 75 per cent of a gallon (3 quarts) to a case of 100 cans.

Extra Standards.

Cans.—Quarter, high-quarter, and half sizes, plain or decorated.

Fish.—Not less than 5 to a can, preferably from 7 to 10. May be steamed, preferably fried in oil, and carefully packed brights up.

Oil.—Winter yellow cottonseed, or corn, not less than 87.5 per cent of a gallon (3½ quarts) to a case.

Fancy.

Cans.—Quarter, high-quarter, and half sizes, plain or decorated tins, brass label, or wrapped and labeled.

Fish.—Not less than 7 to a can, preferably from 10 to 15. Cut and eviscerated, fried in oil, packed brights up, carefully, neatly, and attractively.

Oil.—Winter yellow cottonseed, corn, or olive, at the rate of 87.5 per cent of a gallon (3½ quarts) to the case.

Extra Fancy.

Cans.—Quarter, high-quarter, and half sizes, plain or decorated tins, brass label, or wrapped and labeled.

Fish.—Not less than 7, preferably 12 or more. Cut and eviscerated, fried in oil, and well packed.

Oil.—Olive, at the rate of 3½ to 4 quarts to a case.

STANDARD QUARTER OILS.

Since the grade called standards at present constitutes by far the greatest part of the pack, it may suffice at first to urge a standardization of this, the poorest grade, and allow the other grades to take care of themselves as the marketing conditions and the ideas developed by the new demands dictate. The following specifications for "standard quarter oils" are therefore suggested:

Cans.—Plain or decorated.

Fish.—Not less than 5, preferably 6; more, according to the size of the fish. Steamed and packed brights up, neatly, carefully, and attractively, to show on opening a smooth, bright, clean surface.

Oil.—Prime, summer yellow cottonseed or corn; not less than 75 per cent of a gallon (3 quarts) to a case of 100 cans.

Criticism of the number of fish to the can may be made, owing to the fact that in some seasons it would be difficult to obtain fish of proper size for packing the various grades. Two sizes only, however, are strictly specified. When fish of a more suitable size can be obtained preference is given for larger counts in the respective grades, so that these fish may be packed to better advantage by placing them in a higher class of goods than is done at present.

The too prevalent practice of packing the fish in the cans backs up undoubtedly originated in an effort on the part of the canner to conceal damaged and inferior (belly-broken) fish, and in many canneries it is still done for this purpose. Many cases of sardines which could have been packed brights up were found, however, packed backs up. Undoubtedly a number of fish which are not too badly damaged could be packed backs up to make a wholesome product, thus eliminating some waste. Such a product should be sold for just what it is and not in competition with better grades. In any system of grading that may be adopted *all sardines that are packed backs up should be classed as seconds.* A premium would then be established for packing brights up and a better appearing pack assured.

A standard for the three-quarter mustard sardines, based on the size of the fish, should be adopted. Under present conditions relatively large fish are called herring when packed in round No. 1 cans and sardines when packed in mustard sauce in the square sardine can. The sardine is generally regarded as a small fish, and it is important that the canner do nothing to prejudice the consumer against his goods by abusing this justly prevalent idea, such as packing as sardines three or four tailpieces cut from large fish.

Poor quality and overproduction, two prominent factors in the fluctuation of the prices of sardines, may be overcome to a great extent by the adoption of standards of quality. A big season's catch may thus be utilized in several different classes of goods instead of in one grade, making the pack more elastic and at the same time establishing a better quality in the poorer grades.

It is believed that the production of a pack of sardines of specified standards of quality will in time create a demand for them which will always exceed the supply. At the same time it will bring about a better condition in the marketing of sardines by placing them in the class of staples which can be sold on merit and which the trade will buy because there is a demand for them. It will also tend to eliminate the speculative feature now unfortunately present when the jobber waits till the price suits him before buying.

SANITARY PRECAUTIONS IN PACKING SARDINES.

THE WATER SUPPLY.

The water supply of the canneries is obtained from the beach through a pipe, the opening of which usually is a few feet below the level of the water at low tide. The depth to which this pipe extends varies from being completely out of the water to several feet below, depending upon the location of the cannery and the slope of the beach. At some canneries the intake pipe was found to be in too close proximity to the sewer outlets or to the drainage from the outdoor privies attached to the cannery. Table 41 shows the results of a bacteriological examination of representative cannery water supplies.

TABLE 41.—*Bacteriological examination of the water supplies from representative sources around Eastport, Lubec, and North Lubec, Me. (Sept. 18, 1916).*

Source.	*B. coli* present in—		
	5 cc.	1 cc.	0.1 cc.
North Lubec, Me.:			
9.20 a. m., low water	+	0	0
8 feet from mouth of pipe, low water	+	0	0
Lubec, Me.	+	+	+
Very near sea wall	+	+	+
	+	+	+
Eastport, Me.:			
Near north end of town	+	+	0
	+	+	+

DISPOSAL OF SWELLS.

Swells are caused by the activity of a specific bacterium found in and near the canneries, and associated also with the feed of the small fish. At many canneries the returned swells are dumped into the water near the cannery.

When loaded into scows the discarded fish and cuttings from the packing tables often are spilled near the wharves. If the collection of this material becomes too large before it is convenient to remove it, it may be thrown overboard below the cannery, where it furnishes an excellent medium of growth to the organisms present in the cans of swells. At low tide any contamination on the beach is gradually washed back by the receding water, and concentrated near the openings of the intake pipes. Thus the cycle of infection from the returned swells is completed when the bacteria causing them are pumped up through the intake pipe in the canneries, to contaminate the fish which will produce more swells.

Contamination of the pack in this way may be eliminated only by using fresh water free from pollution. The reprehensible practice of throwing out upon the beach near the canneries returned swells, discarded fish, and waste portions and viscera of the fish should be abandoned. Moreover, the opening of the intake pipe through which the water supply is pumped should be far enough offshore and at a sufficient distance from sewer openings to insure water free from contamination.

BOATS AND TANKS.

In some of the canneries not enough attention is given to keeping the holds of the boats and the pickling tanks clean. In order that the fish may arrive at the canneries free from any contamination from the boats, the tanks in the boats should be inspected, to see that they are thoroughly clean and sweet before the fish are put into them. These tanks should be absolutely tight to prevent any leakage into the bilge to contaminate the ballast. The bilge and ballast should always be kept clean. The sluices, pickling tanks, carriers, cutting sheds, and benches should be thoroughly washed after each operation, and no fish, parts of fish, or brine should be allowed to remain in them.

FLAKING MACHINES.

After each operation the flaking machines should be washed with a stream of water of sufficient force to cleanse them thoroughly and to dislodge any fish adhering to them.

In the past the unclean condition of the flakes has been one of the greatest sources of damage to the appearance of the sardine pack (Pl. XV). Particles from dirty flakes and dirt and débris adhering to the hands of those manipulating the flakes find their way into the cans with the fish, to the great detriment of its appearance. The flakes should be thoroughly cleaned after each operation, and no particles of fish from the previous operation should be allowed to remain on them.

PANS.

The pans used for holding the packed cans should receive the same care as the flakes, and should be provided with some means of support, so that when they are stacked no pan shall touch the fish in the cans immediately below it. Negligence of these precautions gives another chance for spoiling the appearance of the packed goods by incorporating in the pack particles rubbed from the pans on the fish in the cans and by marring the fish with the bottoms of the pans. The packed goods should be kept covered at all times and should be removed from the packing room before any sweeping or cleaning is done.

PACKING.

The packers should be instructed to wash their hands in running water often enough to keep them free from bits of the fish which unavoidably adhere to them. Roller paper towels, paper napkins, or some other means for drying their hands should be provided. They should handle nothing but the fish and cans while packing, and the fish as little as possible, exercising great care that the skin of the fish is not broken or damaged. In cutting (shearing) the fish, when done from the flakes, the heads and tails should be kept in one pile and the main portion of the fish, used in packing, in another pile, thus facilitating packing and keeping particles of refuse, heads, and tails, and small débris from adhering to the fish and entering the cans, to spoil the appearance of the finished product.

STORING THE EMPTY CANS.

In a majority of the canneries no special provision is made for suitable storage of the empty cans. The cans, particularly the covers, are often stored in some unused portion of the cannery where dust and dirt accumulate. An improvement could be made in the condition of the cans as they sometimes leave the can factory. The shooks as they are made up often contain a quantity of sawdust, a large part of which is contributed by the covers. When the covers are nailed on and during subsequent handling the sawdust is shaken into the cans, where it adheres to the thin coating of oil covering the tin plate. When this oil dries, it is impossible to remove the adhering dust and other dirt which may have accumulated.

An effort should be made to improve these conditions. Placing the cans in the shooks upside down—that is, with the bottoms facing the cover of the shook—and keeping the shipping case in this position afterwards will prevent the sawdust from entering the can. When stored in the canneries the covered shooks should be in a dust and dirt free place, or should be kept covered with material which will prevent the entry of dust and dirt.

SEALING THE CANS.

In the course of the investigation many instances of improper sealing were found. Unless the closest attention is given to the machines of the first two types mentioned on page 10, particularly to the adjustment of the rolls and the compression jaws, the cans are but imperfectly sealed. It may be possible in the future to render cans sealed in this way tight by providing them with gaskets or with a preparation on the covers which will form a gasket, approximating the seal obtained on the hermetically sealed soldered cans. A poorly sealed can permits leakage of oil, as a result of which the product may reach the consumer in a very unsightly condition, lacking in some of the original food value, and sometimes with the contents contaminated or spoiled.

CLEANING THE CANS.

The unattractive, unclean condition of packed cans has been a point of severe criticism on the part of the wholesale and retail dealer, and has done much to bring American sardines into disrepute. It is caused by permitting the cans to leave the factories without having been properly cleaned, or, if cleaned, so poorly sealed that oil can leak over all the cans in the shook.

As a rule, the cans of sardines are cleaned by shoveling them over with sawdust or rolling them through sawdust (Pl. VIII, fig. 1). When the cans are bumped and rattled about during shoveling or when passed through revolving sawdust cleaners the fish, even if well packed, become disarranged, and leaks often occur because of dented seams. To prevent disarrangement of the contents those packers who maintain a definite quality, and who take pains to place the fish in the cans neatly, carefully clean the exterior of the cans before shipping them. Cleaning the cans may be done mechanically by passing them through a hot water bath containing soda lime and rinsing them afterwards with hot water.

WASTE IN PACKING SARDINES.

ELIMINATION OF UNNECESSARY WASTE.

Carelessness in attention to details which would eliminate waste and wasteful methods are too common in the sardine industry. For the most part, this is the result of a desire to turn out large quantities of goods and of a lack of control over labor. The owners and managers of the canneries are often so negligent in enforcing regulations governing employees that wasteful methods have developed from careless operators, and the quality of the finished product has been impaired. In regions where sardine canneries are numerous, uniform rules and conditions of labor are badly needed. The standard for discipline and the enforcement of rules can never be higher than that permitted in the plant which is the most lax in these matters. On the manufacturing side, the principal sources of loss in the industry are the waste of fish and oil, in the case of the raw material, and rough and inefficient handling of the equipment of the plants. These of course are not found to the same degree throughout the industry.

The waste of fish may be due to (*a*) cutting back fish of large size to pack in quarter-size cans; (*b*) discarding on the flakes fish that are suitable for packing; (*c*) using feedy fish; (*d*) using fish (britt) that are too small for packing by the methods employed in the industry. The waste in cutting back fish of large size to pack in small cans is very generally found. That due to negligence on the part of women packers in discarding fish that are suitable for packing can be corrected by stricter discipline.

Some concerns persistently accept feedy fish, which means that they pack a great many broken and damaged fish to the detriment of their own particular goods and of the sardine industry in general.

The lack of cooperation among the packers permits different standards in the quality of the output, and makes it difficult for a few packers to maintain a standard of quality. On a hostile, competing basis, fish that are refused at one cannery as unfit for packing are frequently accepted by a competitor, who cares little for quality, or who may have different ideas as to what constitutes a certain standard. Under such conditions the standard can never rise far above that adopted by the packer who has no consideration for the quality of his pack.

The waste of oil through spilling from the cans after the fish have been packed and oiled is found in varying degrees among the different canneries, and is directly chargeable to the lack of strict supervision of those employees whose duty it is to fill the cans with oil and of those who handle the filled cans.

WASTE IN CUTTING BACK FISH TO PACK IN QUARTER-SIZE CANS.

Data were secured to show the waste occurring when fish of large size were cut in various ways to fit the can, and the use of a can of larger size to fit these fish was considered.

A high-quarter long can (Pl. XX, fig. 1), made to hold large fish without cutting away the best portions of the flesh, has the same dimensions in height and width as the ordinary high-quarter can, but is 1 inch longer. The larger fish (7 and 8 inches long), which at certain times are the only ones obtainable, can be packed more economically in this can. One of the most striking features in the preparation of sardines is the enormous waste of edible material caused by packing such fish in the common quarter oil size can (Pl. XX, fig. 2). Fish 7 and 8 inches long were cut back in different ways to properly fill the suggested higher and longer can and the ordinary low-quarter can (Pl. XXI). To fit the new type of can the 7-inch fish is cut directly back of the gills, with the tail trimmed, thus eliminating all waste of edible material. If the tail is not trimmed, a small piece of edible material is lost in cutting (Pl. XXI, fig. 1). In cutting fish of this size to fit the ordinary quarter oil can, a large amount is wasted (Pl. XXI, fig. 1, central figure). Practically half of this waste may be saved by trimming the tail of the fish when packing in the low-quarter can.

With 8-inch fish no waste occurs when the tail is trimmed and the fish cut to fit in the larger can (Pl. XXI). When the tail is not trimmed a certain amount of waste results (Pl. XXI, fig. 2). When cut according to present practice, tail untrimmed, to pack in the ordinary low-quarter oil can, practically one-half, and the best meaty portion of the fish, is discarded. By trimming the tail and cutting to pack in the ordinary quarter size can, nearly one-half of this waste can be saved. The amount thus saved is practically the same as that obtained by cutting, with the tails untrimmed, to pack in the suggested longer can. A greater saving is effected by the use of this can with the 8-inch fish than with the 7-inch fish.

The saving in material which may be obtained by the use of a can to fit the fish, rather than cutting the fish to fit the can, is strikingly shown in Plates XXII and XXIII, where the determination of the amount of waste was actually made on a number of fish 8 inches long, cut in the manner described to pack in the longer can and in the ordinary quarter oil size can. Figure 1, Plate XXII, shows the minimum waste, 19 per cent, of heads, and a portion of the tails only, of fish which had been cut and the tails trimmed to pack in the high-quarter long can. Fish cut in this manner will pack five to the can, with no waste of edible material.

The maximum waste, two-thirds of which is edible, was found to be 60 per cent in cutting 8-inch fish with the tails untrimmed, according to present practices, to pack in the ordinary low-quarter can (Pl. XXII, fig. 2). Fish of this size, cut in this manner, pack only four to the can. Tons of good food material obtained in this way (Pl. XXII, fig. 2, left-hand pan) are emptied into scows to be carried away to be made into fertilizer, or are simply thrown away.

When 8-inch fish, with the tails trimmed, are cut and packed in the ordinary can, the waste of edible material is reduced to 24 per cent, a saving of 17 per cent of edible material (Pl. XXIII, fig. 1). It makes, however, only a 4-fish can. Practically the same amount of waste of edible material, 23 per cent, is obtained when 8-inch fish, with the tails untrimmed, are cut to pack in the high-quarter long can (Pl. XXIII, fig. 2). Fish of this size, with the tails untrimmed, when packed in the longer can, make a 5-fish can, which is more desirable from all standpoints than the 4-fish can. Plate XX, figures 3 and 4, shows an ordinary low-quarter can and the suggested larger can, packed with 8-inch fish. When packed with fish of this size, the smaller can holds only four pieces, whereas the larger can holds five fish, the entire edible portion of which is utilized.

The waste thus shown is all the more deplorable when the fact is considered that the fish have already gone through the greater part of the process and need only to be placed in cans of the proper size to be entirely utilized.

From the packers' standpoint, a legitimate objection to the adoption of cans radically different in dimensions from those in ordinary use may be raised. The appliances for handling, and the machinery adapted for sealing the cans are standardized. The use of this new longer can would necessitate a refitting of the carrying table, the chuck, and headpiece of the sealing machinery, which in certain cases would be an expensive undertaking. The old type single spindle machine, which is fed by hand and would require only a chuck and headpiece in order to adapt it for use with this can, could, however, be used. In several of the canneries some of these old type closing machines are now in use; in others they are stored away. An effort to introduce sardines in these larger cans to the trade could be made to good advantage.

The fact that the objectionable 3- and 4-fish cans of domestic sardines would be eliminated should make worth while the use of the larger cans.

Other cans now in use, notably the high-quarter and the half-oil size, may be employed to effect a saving of part, at least, of the waste just discussed. There appears to be no mechanical difficulty in packing, sealing, and preparing for shipment the high-quarter and half-oil cans (Pl. IX). The high-quarter cans are a very desirable size

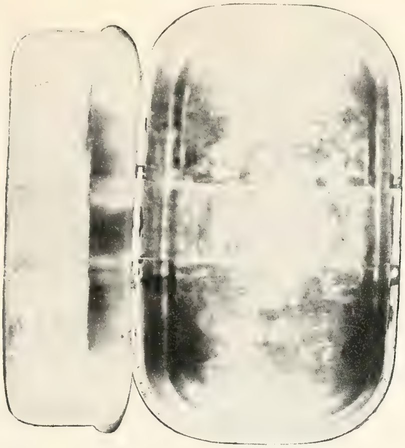

FIG. 1.—HIGH-QUARTER LONG SARDINE CAN.

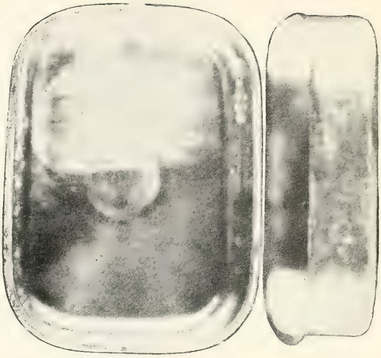

FIG. 2.—ORDINARY LOW-QUARTER OIL SARDINE CAN.

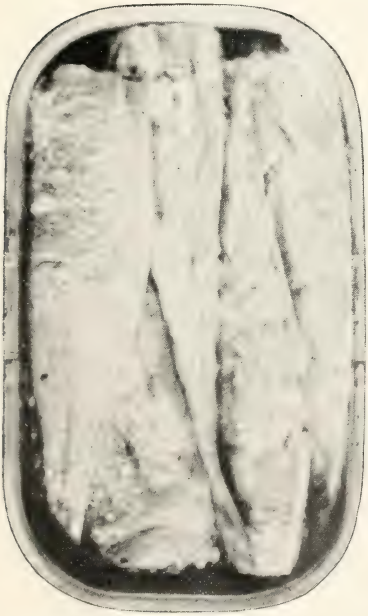

FIG. 3.—FIVE 8-INCH FISH PACKED IN A HIGH-QUARTER LONG CAN.

No waste of edible material.

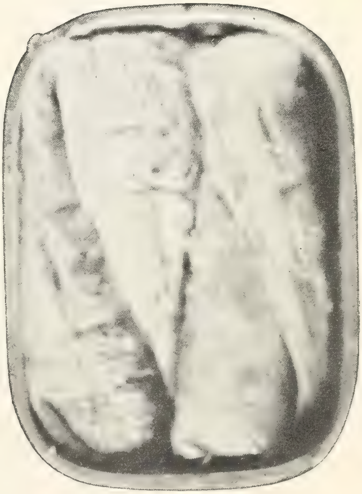

FIG. 4.—A 4-FISH CAN. ORDINARY QUARTER OIL CAN, PACKED WITH 8-INCH FISH.

Waste of edible material, 41 per cent.

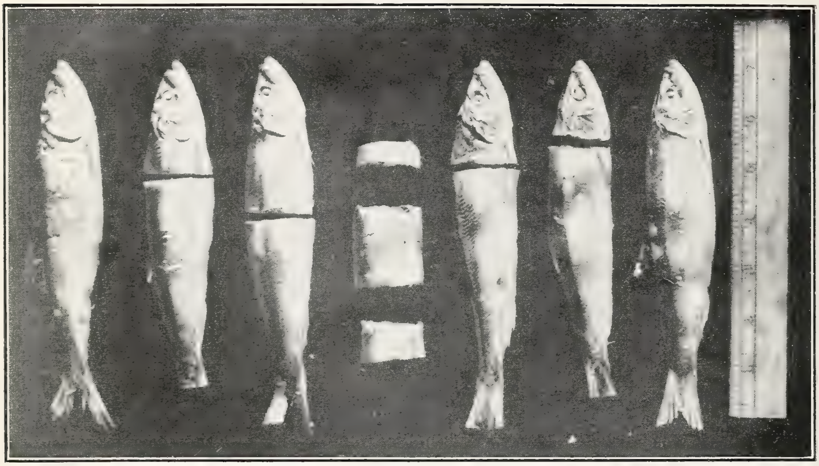

FIG. 1.—CUTTING 7-INCH FISH.

Waste when packed in quarter oil cans (left), as compared with that when packed in larger cans (right).

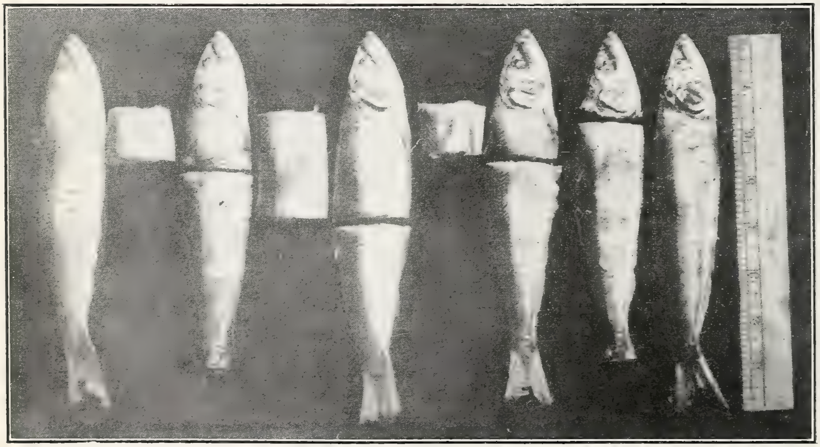

FIG. 2.—CUTTING 8-INCH FISH.

Waste when packed in quarter oil cans (left), as compared with that when packed in larger cans (right).

MANNER OF CUTTING BACK FISH.

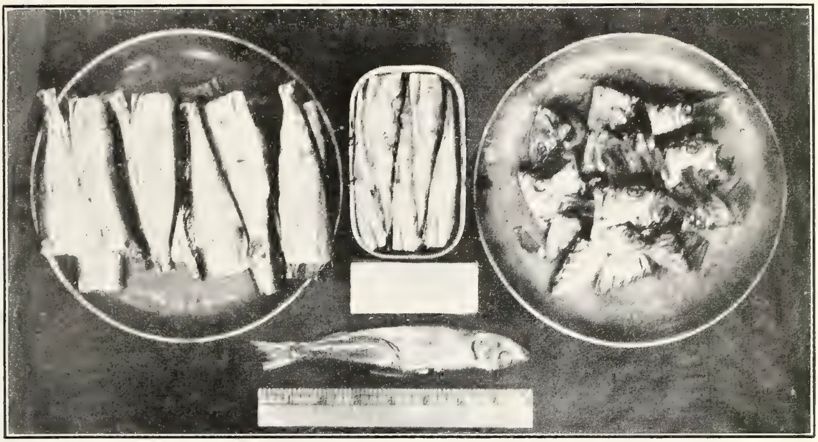

FIG. 1.—MINIMUM WASTE (19%) WHEN 8-INCH FISH ARE CUT AND HAVE TAILS TRIMMED TO PACK IN HIGH-QUARTER LONG CAN.

No waste of edible material. Five fish to the can.

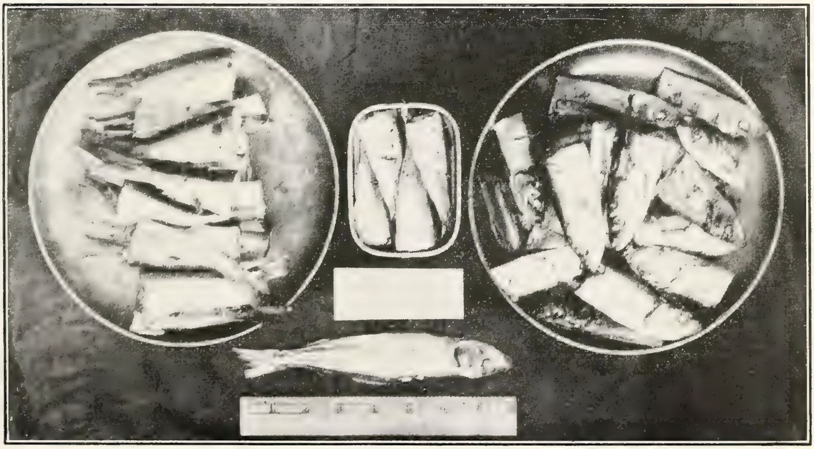

FIG. 2.—MAXIMUM WASTE (60%) OF EDIBLE MATERIAL WHEN 8-INCH FISH ARE CUT, AS IS NOW THE CUSTOM, WITH THE TAILS UNTRIMMED, TO PACK IN AN ORDINARY QUARTER OIL CAN. FOUR FISH TO THE CAN.

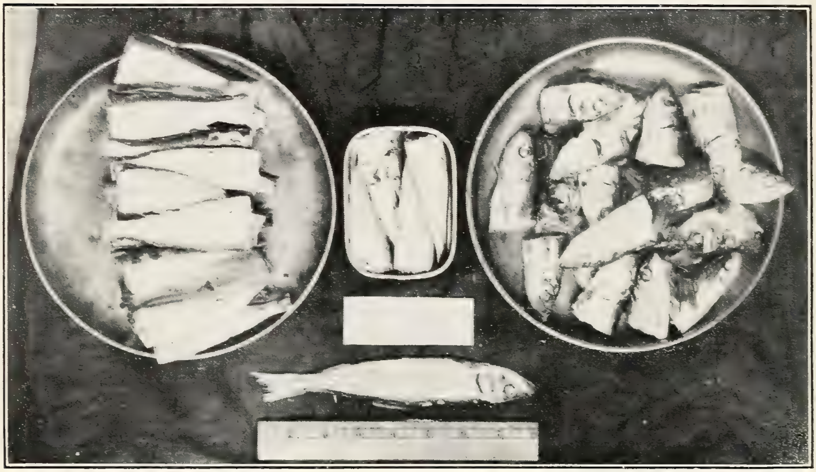

FIG. 1.—EIGHT-INCH FISH, TAILS TRIMMED, CUT TO PACK IN ORDINARY QUARTER OIL CAN (TOTAL WASTE, 43%, WASTE OF EDIBLE MATERIAL, 24%). FOUR FISH TO THE CAN.

Trimming the tails results in a saving of 17% when fish of this size are packed in quarter oil cans.

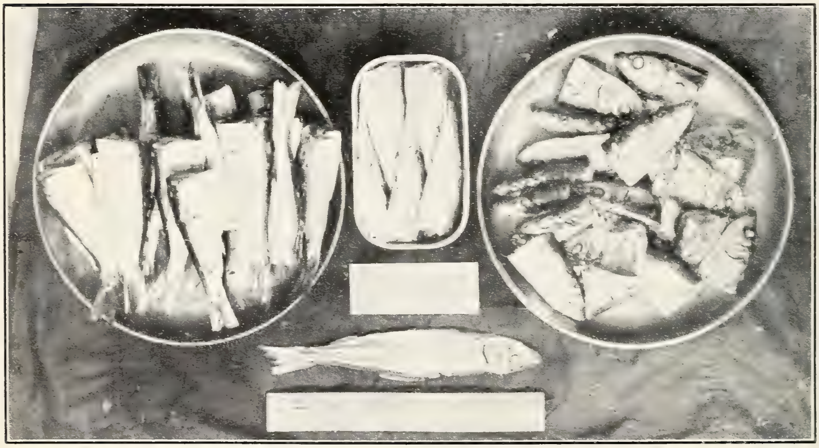

FIG. 2.—EIGHT-INCH FISH, TAILS UNTRIMMED, CUT TO PACK IN HIGH-QUARTER LONG CAN (TOTAL WASTE, 42%, WASTE OF EDIBLE MATERIAL, 23%). FIVE FISH TO THE CAN.

and furnish a quality of sardines which should be most attractive to the purchaser.

Although not quite as long, and hence not as economical in packing the larger fish, the half-oil can may well take the place of the one that has been suggested. The high-quarter cans have been successfully used by some of the canners during the past few seasons. The 1-pound and the half-pound oval cans deserve consideration for packing large fish. Oval cans are coming into use at one or two of the sardine canneries on the Maine coast. The quality of the sardines packed in them would suggest that they are being well received by the trade.

Utilization of Large Fish in Special Packs.

To do away with the waste which occurs when only fish too large for packing in the ordinary sardine can are available, various special packs may be made.

KIPPERED HERRING.

Some of the large fish which at certain seasons and in certain places are the only ones obtainable may be used to excellent advantage in the form of kippered herring. Fish that necessitate cutting back to such an extent that there is a large waste of edible material when packed in the cans at present in use, furnish the proper minimum size to use for this product.

Directions for preparing this product are given by Charles H. Stevenson(30).

> Comparatively few kippered herring are prepared in the United States, the round bloaters being so much more popular. The kippered herring are split along the back from the head to the tail, like mackerel, eviscerated, washed, and salted in a manner similar to that applied to bloaters, except that they are not kept in the pickle so long. They are next hung up to dry for a few hours, then smoked for six or eight hours at a temperature of 80° or 85°, each fish being suspended by the napes to keep its abdomen open. With the exception of splitting, the cure is similar to that of bloaters. * * * Herring put up in this way are in great demand everywhere and are preferred by many to the bloater. The very best herring are required for the kippering process. * * * The fish used for kippers should be had as soon as possible after they are taken out of the water. * * * Herring put up in this way are most delicious. * * * The same materials are used for smoking kippers as are used for smoking bloaters and the same conditions apply, only that kippers, presenting a larger surface to the smoke as they do, do not require to be so long exposed to the smoke. As in the case of bloaters and red herring, the tastes of the consumers must be ascertained and the curing as to salt and smoke regulated accordingly. The manufacture of kippers is greatly on the increase in Britain. It is an important branch of the herring industry and utilizes a large proportion of the British catch of herrings.

Many of the Maine canneries are already provided with facilities for smoking fish, and those not so equipped might utilize part of the drying ovens and spaces for this purpose, making the expense of installation of suitable equipment a negligible factor. The preparation of kippered herring is comparatively simple and inexpensive, and experimental packs made during a lull in the packing of sardines showed that an excellent quality can be produced on our eastern coast. Kippered herring is one of the best products for which the herring may be utilized. It is believed that there is an excellent opportunity to prepare this food product on a larger scale than has heretofore been done in this country and that it will provide a means for the sardine packer to utilize large fish to a better advantage than heretofore, thus adding to his present profits.

RUSSIAN SARDINES.

In 1870 the importation of Russian sardines into the United States amounted to 50,000 kegs a year, coming for the most part from Hamburg. The disturbed trade conditions arising at that time stopped the importation of this product, whereupon an attempt was made to supply the deficiency with a domestic article. That this enterprise was successful is shown by the fact that in the late nineties some 60,000 7-pound kegs, worth approximately $27,000, of Russian sardines were prepared annually in this country. By 1900 the industry had become quite important, but the next 10 years showed a rapid decline, until in 1913 practically none of these sardines were produced here. The imported article had taken the place of the domestic product. It is believed that many of the fish too large to be packed as ordinary sardines now might well be put on the market in the form of Russian sardines.

Conditions are now similar to those which inspired the production of Russian sardines at Eastport in 1874. The foreign supply is again shut off, or greatly curtailed, and an unusual opportunity is presented to win back and hold a market in a food product which has once been won and lost.

Stevenson has discussed the method of preparing Russian sardines (30), as well as methods for making somewhat similar products known as Mätjeshering and spiced herring.

MÄTJESHERING.

Fresh full herring, both spawners and melters, are well washed, and the gills, stomach, and intestines are removed in such a way as not to necessitate cutting the throat or abdomen, this being accomplished by pulling them through the gill flap. The fish are next immersed for 12 or 18 hours in a 7 per cent solution of white wine vinegar, from which they must be removed before the skin becomes flabby and be wiped dry and covered with a preparation composed of 2 pounds of salt, 1 pound of powdered sugar, and a small quantity of saltpeter, this quantity being sufficient for 75 herring. The fish are then packed in a barrel as upright as possible, in layers, with a sprinkling of salt over each. The following day the fish are returned with the original brine to the barrel, which is sealed. When there is not sufficient brine to fill the barrel, additional should be made of 1 part of the above mixture and 4 parts of water which has been boiled.

SPICED HERRING.

Spiced herring (Gewürzhering) are prepared in Germany in the manner above described, with the addition of spices mixed with the salt. The spices commonly used consist of 1 part of Spanish pepper, 5 parts of white pepper, 4 parts of cloves, 2½ parts of ginger, an equal quantity of mustard, and a particle of mace and of Spanish marjoram, with a few bay leaves scattered between the layers.

Some years ago one of the sardine-packing companies built up an attractive trade in spiced herring. Although the supply of fish for this product was not as uniform as could be desired, as many as 5,000 cases were prepared and sold in one season. The scarcity of fish made it difficult to supply the demands during the next season. The trade in spiced herring was finally ruined by unscrupulous canners, who packed salt herring in round cans and misbranded the product as spiced herring. It should not be difficult to create a new demand for this product.

ROLLMOPS, HERINGSROULADE, ROLLHERING, BISMARCKHERING.

These names are applied to whole or halves of herring which are rolled up with a highly seasoned filling and bound together with twine or held together by little wooden skewers, packed in wooden boxes, and a sauce poured over them. For the most part salt herring are used in their production. The methods for their preparation are given by Viktorin(35) as follows:

1. Fine, large salted herring are washed, the heads are cut off, the bodies split, the bones taken out, and the skins taken off. They are then placed in fresh water for 24 hours. The inside of the herring, now clean, is rubbed with onion sprinkled with pepper and rolled up from tail to head. These rolls (Rouladen) are then cut into two or four cross sections and laid for 8 to 14 days in vinegar which has been boiled and allowed to cool.

2. The heads, tails, and entrails of salted herring being removed, they are washed well and allowed to remain in water for 24 hours. The fish are cut along the belly, laid out back down and pressed out flat, the backbone and ribs are completely and easily removed if a hot iron or cloth dipped in hot water is laid on the backs. Upon each herring there is placed a slice of cucumber, several small onions (or a larger one cut up), some Spanish peppers, and a little piece of lemon. It is then rolled up from head to tail with the skin out and tied with a thread. Prepared in this manner the fish are placed in pure wine vinegar for two days. After the expiration of this time the rolls (Rouladen) are packed symmetrically in boxes and a sauce is poured over them made as follows: For 100 herring, the roe of three is mixed with vinegar to form a mush which is forced through a sieve. Two and one-half liters (approximately quarts) of pure wine vinegar is heated with some tarragon, lavender, bay leaves, and Spanish peppers. The mush of roe, with 100 grams of sugar, is then added, the whole thoroughly mixed, and when cold it is poured over the herring laid in the box.

The herring are put in water for 24 hours, changing the water occasionally. They are boned and prepared in the same way as "Appetitsild," except they are not skinned. The strips are laid on the table with the skin side down. The upper surface is strewn with small cubes of gherkin and onion mixed with pepper and mustard. Roll up the pieces and fasten with a skewer or thorn. As a pickle use a good vinegar, which may be treated with tarragon.

In place of onions a thick tomato sauce or grated horseradish may be used on the herring, or they may be heated and filled with finely chopped celery. In any case a little pepper, cinnamon, and mace should be sprinkled on them. Rollmops prepared in this way should be laid in vinegar which has been cooked with tomatoes, celery, or horseradish, and there may even be added some Worcestershire sauce.

STUFFED SARDINES.

In the preparation of the experimental packs, designed for use in studying the utilization of edible waste in the packing of sardines, a few packs which were classed as "stuffed sardines" were made. If the heads of the raw fish are cut off properly, the viscera can at the same time be entirely withdrawn, leaving the stomach cavity intact. As the name suggests, the interior of each fish, beheaded and entirely free from all the viscera, was filled with various ingredients, and then packed and processed. The methods employed with the small packs made to determine the practicability of preparing such a product were as follows:

After removing the heads of and eviscerating firm, plump fish, quarter oil size, they were thoroughly washed in dilute pickle, and then allowed to remain in moderately weak pickle for 5 minutes. On removal from the pickle they were rinsed for an instant in clear water. The stomach cavities were then packed with the material desired. Next the stuffed fish were placed upon flakes and grilled over a moderately hot fire by passing through a Ferris wheel oven dryer for 15 minutes. After cooling slightly the fish were packed in quarter size cans, and olive oil was added. They were processed 2¼ hours at the temperature of boiling water.

The materials used for stuffing the different packs of fish were chowchow, ground stuffed olives, sweet pickles, sour spiced gherkins, pickled onions, and pepper sauce (p. 110), respectively. These relishes were finely ground before being inserted in the fish.

Samples of these packs were submitted to a number of persons, ignorant of the method of packing and the ingredients used, for an expression of opinion as to the quality. The packs prepared with chowchow and pepper sauce were unanimously regarded as far superior to any of the others, chowchow being considered the best of all. Ground stuffed olives as a filling were also favorably received, ranking third. Samples of the packs with chowchow, submitted to the buyers of an eastern firm which handles exceptionally high-grade fancy grocery products, were pronounced very good. The buyers stated that they could place a product of this character on the market, and would be willing to give it a trial if it ever became available.

No great difficulties need be overcome to prepare and pack stuffed sardines, but the process would be somewhat tedious and the output necessarily limited. Great care in preparation and in attractive packing would be essential. A small device to aid in inserting the filling material into the interior of the fish would be necessary, the form and character of which would readily suggest itself if the project were undertaken. The only question from the packers' standpoint in regard to packing stuffed sardines is whether they can spare the time and attention required to produce them. There would be no trouble in securing a market for them.

UTILIZATION OF UNAVOIDABLE WASTE.

Sardine Paste and Deviled Sardines.

Much of the edible portion of the large fish, now wasted in cutting them back to fit the small cans, may be made available as a wholesome food product in the form of a paste or as deviled sardines. Several experimental packs of sardine paste were put up according to a recipe taken from "Die Merresprodukte," by Heinrich Viktorin (35) with a few modifications, as follows:

Add to 1 kilogram (1,000 grams or 2.2 pounds) of ground fish meat, free from bones:

- 3.5 grams (0.123 ounce) white pepper
- 2.0 grams (0.07 ounce) ginger
- 2.0 grams (0.07 ounce) cloves
- 1.0 gram (0.035 ounce) mace
- 1.0 gram (0.035 ounce) cinnamon
- 1.0 gram (0.035 ounce) allspice
- 100.0 grams (3.51 ounces) butter
- 10.5 grams (0.37 ounce) salt
- 215.0 grams (7.56 ounces) olive oil

The flesh from the large middle part of the fish, cut away in packing the large sizes, was taken from the flakes as they came from the packing tables, so that it was steam cooked and dried to the same degree as sardines. After the meat had been separated from the bones, an easy matter, as the sections readily divide into two portions along the "line of cleavage" between the bones, it was passed through a meat chopper two or three times until thoroughly ground. The spices were then added and thoroughly mixed with the meat by again being passed through a meat grinder several times. The butter, in a semimolten condition, was added, then the oil, and the whole mass again passed through the meat chopper two or three times, until it was thoroughly mixed and finely ground. This made a quantity sufficient to pack 12 of the small round No. $\frac{1}{4}$ sanitary cans, having a net weight of 3$\frac{1}{2}$ ounces.

It is believed that by increasing the quantity of oil it would be possible to eliminate the butter in this formula without seriously affecting the quality of the product. Any of the ingredients, particularly the amount of oil, can, of course, be changed. Sardine paste, as the term implies, should be soft in texture. The product made according to the formula given was not as soft as might be desired. It did not flow, and could not be spread as readily after being processed as before. Consequently, when a softer paste is desired, it would be advisable to increase the quantity of oil for this quantity of meat.

A second lot of sardine paste was prepared according to the given formula, substituting corn oil for olive oil. Here again corn oil proved to be excellent. In the opinion of several who tasted the preparation, the corn oil was as satisfactory as olive oil in sardine paste.

The following formula was used in the preparation of a small quantity of what may be properly termed deviled sardines:

Add to 1,000 grams or parts:
  500 grams or parts of olive oil
  220 grams or parts of pepper sauce
  27 grams or parts of salt

Pepper sauce.—Chop fine equal parts of green and red peppers and onions. Cover with water, bring to a boil, and then pour off. To one dozen each of the peppers and onions, add 2 cupfuls of sugar and 4 tablespoonfuls of salt, dissolved in 3 pints of vinegar. Then boil the mixture about 1¼ hours. Larger quantities may be made in the same proportions.

This preparation imparted a delightful flavor to the fish. The fish meat was obtained and prepared in the same manner as that used in making the sardine paste.

To devise a simpler recipe for sardine paste, or deviled sardines, a small quantity of paste was made by adding to the fish meat, free from bones and ground thoroughly, pepper and salt for flavor, and oil to bring it to the proper consistency. The ingredients were added in the following proportions:

1,000 grams or parts of finely ground fish meat
5 grams or parts of white pepper
12 grams or parts of salt
530 grams or parts of corn or olive oil

This was well mixed and rendered fine by passing it through the meat chopper a number of times, after which it was packed into cans. This product did not compare in flavor with that prepared by either of the other formulas. It would, however, serve as a very satisfactory cheap food product, and, if prepared attractively, would meet the demand of a class of people who should be supplied with wholesome food of high nutritive value at a low price.

In the preparation of these pastes, it was noticed that the portions of meat taken from the larger fish gave more satisfactory results than those taken from the small fish. With the idea of using the waste which is so enormous when feedy fish are taken, one experimental lot was prepared from the ground meat taken from feedy fish having the bellies badly broken. When ground, however, this produced a dark-colored, unattractive mass. In the preparation of the paste or the deviled sardines, meat from the large fish should be used to impart the proper color and taste to the product. It is impossible to make a satisfactory food product from the small fish which have been ruined through the action of feed.

The time and temperature necessary for complete sterilization of these products were not determined. Some of the preparations processed at 212° F., for from one to two hours, were not sterile when examined bacteriologically six months later, but had not swollen during this time. The contents of cans of a product similar to the deviled sardines which had been processed at 240° F. for from one to two hours also contained bacteria. It is difficult to properly sterilize products of this nature. Before attempting to prepare them, experimental packs should be made to determine, by bacteriological control, the time and temperature necessary to insure complete sterilization. It would be unsafe to try to market a canned product unless it was sterile.

A product as easy of preparation as the deviled sardines, but superior in flavor and quality, was prepared from the square or rectangular sections of meat obtained by carefully splitting the waste pieces of the fish down the backbone, thus dividing it into two sections, and leaving the bone and a portion of the viscera. These sections were neatly packed in sanitary cans and sardine cans, and covered with a sour spiced vinegar. A sweet spiced vinegar used for a small pack was found to be unsuitable for this purpose.

The cans and contents were processed by first venting and heating for 20 minutes at 220° F., then closing the vent and again heating the cans at 220° F. for 30 minutes. Examination was not made to see if complete sterilization was effected.

FERTILIZER.

The waste residue from fish and whole inedible fish have long been used in the manufacture of pomace or fish scrap, to be incorporated in commercial fertilizers. One of the sardine packing companies at Eastport operates a reduction plant for the pressing and drying of waste from the packing houses for a fertilizer ingredient. To supply the fertilizer factory this company also purchases the raw waste material from several of the other canneries in the vicinity of Eastport and Lubec. This plant is housed in a substantial concrete structure, is well equipped, and manufactures a very good grade of fertilizer fish scrap. Prior to the season of 1915 this was the only instance along the coast where a concerted effort was made to utilize the waste as a by-product of the canning of sardines. During the two following packing seasons, however, another company was organized to produce fish scrap for fertilizer from the waste.

FISH MEAL.

Fish meal as a source of protein has been used to a large extent in foreign countries as a supplementary food for stock. It has been used to a very limited extent in this country, and then principally as the protein basis for poultry foods. The use of fish meal in feeding stock and poultry is increasing. A discussion of the use of fish meal for animal feeding and the results of feeding experiments conducted with fish meal made from the sardine waste, the preparation of which is here discussed, has already been published(36).

The waste in the sardine industry offers excellent material for the preparation of a high-grade fish-meat meal. This waste, as it comes from the packing table, has been steam cooked and partially dried, so that it can be taken after collection from the packing table directly to a plant equipped for pressing and drying. The advisability of producing fish meal in a small unit plant attached to the individual canneries or at a central plant devoted exclusively to this purpose is a question for the individual canneries to decide, and depends upon various considerations, such as the location and administration of the plant. Both methods have advantages and disadvantages. It would seem that a cooperative arrangement might be satisfactorily worked out. The prime consideration is to hasten the utilization of the total waste as a by-product for animal feeding purposes.

Looking toward the utilization of this waste material as a stock food, a quantity of fish-meat meal was prepared in an experimental way during the course of this investigation. Six different lots were made under slightly varying conditions on a small commercial scale, and the yield of the dry material and of the oil determined.

The waste material used in all these experiments was taken directly from the packing tables to a small fertilizer plant previously thoroughly cleaned, which was equipped with an iron steam cooker, a rack, and cloth No. 2 screw press capable of yielding a pressure of 120 tons, and an ordinary type rotary fertilizer drier having a capacity of 1,800 pounds of dry material. Table 42 shows the treatment given the raw material, the composition of the raw material and of samples taken during the process, the method of treatment, and the yield of fish meal and oil.

Lots 1 and 2, which were taken out of the drier much too soon and which therefore contained too much water, did not keep. Lot 1 spoiled in the course of a week and lot 2 in about four weeks' time. The meal from both these lots was discarded.

Since it was desirable to have the moisture content of the material much lower, longer drying periods were adopted in preparing the remaining lots. Drying the meal to a moisture content between 5 and 10 per cent resulted in the product keeping satisfactorily.

The dried meal composing lot 3 had a very strong odor of ammonia when drawn from the drier. This disappeared, however, on cooling and standing overnight. Lot 4 had a faint odor of ammonia when first prepared. No ammonia odor was detected in the two other lots.

The proportion of whole fish composing the waste used in these experiments varied considerably, as did also the oil content. In the case of very fat fish the oil was expressed in a pure condition, mixed with comparatively little water.

TABLE 42.—*Yield and composition of experimental lots of fish meat meal.*

Material.	Composition of raw material before and after pressing and of final product after drying.						Treatment of raw material.						Yield of meal and oil.			Yield of oil.		
	Water.	Oil.	Total nitrogen.	Total protein (Nx 6.25).	Ash.	Total.	Ground or whole.	Steamed or cold.	Steam cooked.	Time of pressing.	Pressure per square inch.	Time of drying.	Weight of raw material.	Weight of dry material.	Yield.			
	P. ct.	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*			*Min.*	*Hrs.*	*Tons.*	*Hrs.*	*Lbs.*	*Lbs.*	*P. ct.*	*Lbs.*	*Gals.*	*P. ct.*
Lot 1:																		
Raw material	57.68	15.45	3.30	20.63	5.68	99.44	Whole	Cold	....	2	120	1½	2,074	[1] 628	[1] 30.28	165	22	8.0
After pressing	57.80	8.07	4.29	27.41	6.72	100.00												
After drying	24.94	15.39	7.34	45.88	11.62	97.83												
Composition calculated to 10 per cent water.	(10.00)	(18.09)	(8.63)	(53.94)	(13.66)	(95.69)												
Lot 2:																		
Raw material—																		
After steam cooking	63.89	12.85	2.82	17.63	4.63	99.00	Whole	Steam cooked	15	1¼	120	2⅛	2,061	[1] 553	[1] 26.83	180	24	8.73
After pressing	57.65	6.76	4.41	27.56	5.48	97.45												
After drying	33.99	12.16	7.10	44.38	8.88	99.41												
Composition calculated to 10 per cent water.	(10.00)	(16.00)	(9.34)	(58.38)	(11.67)	(96.05)												
Lot 3:																		
Raw material—																		
After grinding	58.32	17.22	3.20	20.00	5.21	100.75	Ground	Steam cooked	25	1¼	120	2½	1,567	432	27.57	120	16	7.70
After steam cooking	61.33	13.98	3.02	18.88	5.14	99.33												
After pressing	59.37	6.70	4.26	26.63	6.58	99.28												
After drying	4.90	17.51	9.65	60.31	14.73	97.45												
Lot 4:																		
Raw material—																		
After grinding	56.51	16.49	3.26	20.38	6.19	99.59	Ground	Cold	....	2	120	3	2,197	767	34.91	187.5	25	8.53
After pressing	57.14	7.60	3.96	24.75	7.85	97.34												
After drying	10.83	17.14	8.52	53.25	16.20	97.42												
Lot 5:																		
Raw material—																		
After steam cooking	54.52	9.72	4.07	25.44	9.11	102.86	Whole	Steam cooked	30	1	120	2½	1,777	580	32.64	67.5	9	3.79
After pressing	49.83	6.53	5.10	31.88	10.14	103.48												
After drying	5.38	12.71	9.68	60.50	19.85	98.44												
Lot 6:																		
Raw material—																		
After steam cooking	64.99	8.54	....	....	5.93	....	Whole	Steam cooked	90	2	120	2½-3	3,391	755	22.00	....	....	....
After pressing	56.03	5.38	....	....	12.25	....							13,067	3,715	28.43	....	....	....
After drying	5.16	9.69	10.53	65.81	14.99	95.65									[2] 29.04			
Average composition dried meal.	7.71	15.19	9.39	58.70	15.18	96.78	....	....	....	....	....	....	....	....	....	....	....	....

[1] Calculated as containing 10 per cent water.

[2] Average.

Lot 5 was made from waste obtained from small fish from 3 to 5 inches long (snippers), which would pack from 20 to 25 to a can. This waste material contained from 60 to 70 per cent of whole fish which had been discarded from the packing table because it was decomposed by feed, broken, and damaged.

The waste material used for lot 6 was composed of small fish which would pack 8 to 10 to a can. These fish were very feedy, and had been badly broken during transportation to the cannery. The waste in these fish as actually determined amounted to from 80 to 85 per cent, the largest encountered during the entire investigation. Whole flakes full were discarded at a time.

The results of the analyses made show that a large percentage of oil was removed during pressing, while the percentage amount of water was not appreciably changed. Where the material was steam cooked, the percentage of water increased, and pressing in these instances brought the percentage of water down to practically the same amount as that present in the raw waste as it came from the packing tables. The sum of the constituents—water, oil, protein, and ash—add up to practically 100 per cent in all cases in the results on the raw material, but after drying there is a shortage of undetermined matter of from 2½ to nearly 4 per cent. This difference is in large part due to the formation of nonnitrogenous material during cooking and drying, and in part to the fact that the factor 6.25, used for calculating the total protein from the nitrogen determined, is not exact for fish protein.

The average yield of meal, ranging from 5 to 10 per cent of water, as determined in these six experiments, amounts to 29 per cent. The average would be higher than this by eliminating the last lot, in which the waste was steam cooked an excessive length of time, so that undoubtedly a great part of the protein material was lost in the water which was formed. It is safe to place the yield of material that can be obtained from this waste at 25 per cent under average commercial conditions.

In the case of the oil, cold pressing gave as good a yield as pressing the steam-cooked material. Steam cooking or heating before pressing reduces the time required for pressing. Excessive cooking should be avoided. The yield of dry meal is apparently decreased by material lost during cooking in the excess water formed by condensing steam. The small amount of oil yielded and the comparatively small amount retained in the dried meal made from small fish with a low fat content might suggest to the prospective producer of fish meal that at times in the season, when these fish are plentiful and when they are as poor in fat as those composing lots 5 and 6, it would not be necessary to press them at all before drying the waste for feeding purposes. As much of the oil as possible should be removed by efficient pressing of the raw material. In pressing there is this to be gained, that, if the material has been steam cooked, part of the water is also removed, thus making the time of drying shorter.

Based on a pack of 1,800,000 cases, and assuming that the entire amount of waste would be made into fish-meat meal, and 20 cases are obtained per hogshead, with 1¼ tons of waste for each 15 hogsheads of fish, and that the yield of meal is 25 per cent of this amount, the following amount of meal could be prepared from the waste in the sardine industry: 1,875 tons of meal, which at from $40 to $45 per ton would have an approximate value of $80,000. An estimate based on 1½ tons waste per 10 hogsheads would yield 13,500 tons of waste, which at 25 per cent yield of meal would amount to 3,375 tons. This at $40 per ton would produce a revenue of $135,000. On a basis of 15 gallons of oil per ton of waste there would be in this case 202,500 gallons of oil, which at 20 cents per gallon would be $40,500. On a basis of 10 gallons of oil per ton the revenue on the oil at 20 cents per gallon would amount to $27,000. In round numbers, it is safe to estimate that the utilization of the waste material, such as could now be obtained from the packing of sardines, would yield 3,000 tons of meal and 200,000 gallons of oil. The oil produced in this way is a very superior grade of fish oil, far superior to the ordinary grades. At the 1916 prices of fish oil the oil obtained from rendering the sardine waste should amount to a sum more than sufficient to defray the cost of manufacturing the dried meal.

As a result of this work a system has been installed in one of the canneries for utilizing the waste for fish meal for animal feeding purposes. Reports received indicate that this effort has been very successful.

ECONOMIC CONSIDERATIONS.

BUYING FISH FOR THE CANNERIES.

At present the fish are sold at auction by the owner of the weir, often creating keen competition between the various boatmen who act as the packers' agents. Within certain limits the boatmen are free to bid up the purchase price. As the packer pays the boatman a certain sum for each hogshead of fish transported, the boatman often is tempted to receive this fare without sufficient regard to the quality of the fish or the price asked for them. It would seem most advisable, therefore, to place stricter limitations upon the price the boatmen may bid for the fish, and to refuse to accept fish which are too poor to pack.

NUMBER OF FISH, OF VARIOUS SIZES, PER HOGSHEAD (1,000 POUNDS).

The unit of measure in the Maine sardine industry, the hogshead, is considered in practice to hold approximately 1,000 pounds. Ten tubs of fish of specific dimensions constitute a hogshead. It was shown that the actual weight of a number of tubs of fish, when taken at the weir, averaged more than 100 pounds each. The weight of a hogshead, therefore, should be considered as more than 1,000 pounds. Doubtless these weights vary, and for convenience the numbers of fish per hogshead are given on the basis of a hogshead weighing 1,000 pounds. The figures for the fish were determined by counting several 100-pound lots of fish of various sizes. The following results, in round numbers, were obtained:

Length of fish, inches.	Approximate number per hogshead.
4	51,000
5	33,500
6	22,300
7	9,900
8	7,200

The number of fish 4, 5, and 6 inches in length necessary to fill the quarter size can was found to be, on an average basis, 22, 11, and 8, respectively. With these figures as approximate data, it is possible to estimate the number of cases per hogshead that may be packed from a uniform lot of fish. The more efficient the operation of the factory the nearer to the theoretical the yield should approach.

CAPACITY OF THE CANNERIES.

The sardine canners along the coast of Maine are entirely at the mercy of the run of fish for their supply of raw material. Sometimes in the early spring, and usually from the summer school in August, there is an oversupply of fish, while at other times during a season there is a scarcity. The supply of fish varies during the year and also varies locally, depending upon the places where the different schools strike in.

There is an urgent need for some method to insure a more uniform supply of fish. During a period of overabundance it would be desirable to store the excess supply for use as needed rather than attempt to use all that can be taken from the water, thereby crowding the capacity of the canneries to the detriment of the quality of the finished product. This would be accomplished, to a certain extent, by the use of pounds or pockets attached to the weirs and by floating inclosures made entirely of nets in which the catch of a few weirs could be stored. Cold storage facilities would also very materially aid in solving this difficulty. It is doubtful, however, if the product could legitimately stand this added cost.

Using impounded fish only would insure a nearly constant supply of fish free from feed. Such fish could be taken at the proper time in the morning and in the desired quantity. They could be brought to each cannery in amounts governed by the capacity of the particular cannery. Under the present system the supply depends upon the irregularity of the catch, and the time of delivery is governed by the stage of tide at which the weirs can be seined. Fish beyond the capacity of the cannery are often brought in by the boatman, who is anxious to earn on each trip as large a fare as possible.

The universal application of regulations prohibiting the packing of "feedy" fish, strictly observed, will necessitate the building of pounds on a majority of the weirs. In the interest of efficiency, the elimination of waste, and the improvement of quality it would seem wise to extend the idea a little further and use nothing but impounded fish in packing sardines. Following this, it would be desirable if each cannery were on a capacity basis, taking no more fish than can be properly handled, so as to make a neat, attractive product, according to specifications adopted for the particular grade packed and which can be sealed in a working day of 10 hours.

CARTONS FOR STANDARD SARDINES.

Sardines are packed in tins with the brand name and design printed on the cover or sides, and also in plain tins. The practice of cartoning the standard grade of sardines packed in plain tins has increased rapidly in recent years. The cartons provide a place for the key in the key can goods and conceal unattractive, unclean cans. This is an expensive method of attaching the key and overcoming the difficulty of cleaning the cans. It seems a great waste of effort and material to place the so-called "standard" grade of sardines in cartons. According to present practices, all the different brands of the standards in cartons are prepared from the same grade of standard goods. Although cartoning or wrapping the fancy and extra fancy sardines may be justifiable, the margin of profit in the standard grade does not justify this additional cost on manufacture. It should be put elsewhere in the process to bring about an improvement in quality. It is hoped that the sardine canners will be able to cooperate in this feature of packing sardines, which, through competition, has developed into a wasteful and useless practice, to the end that it may be completely eliminated. This should prove particularly desirable now that labor and paper are high and scarce, and will be an advance in the direction of conservation and efficiency.

IMPORTATION AND EXPORTATION OF SARDINES (1910-1916).

Table 43, prepared from the Annual Reports on Commerce and Navigation of the United States, shows the value of the importations of sardines into the United States, for the years mentioned, from the principal sardine-producing countries. An interesting feature in the value of the sardine importations is the gradual decline in the importations of the French sardine and the increase in the value of the Norwegian product during the years 1910 to 1915. Importations from

Portugal show a slight increase during the last three years over the first three years of this period. The value of the sardines imported from Italy shows a notable increase during 1914, 1915, and 1916, while little change in the values of the fish imported from Spain is seen until 1915, when there was a decided decrease, followed in 1916 by a marked rise.

The total importations from all countries reached, in round numbers, a value of $3,000,000 during 1914 and 1915. The total value for 1915 was a little below that of 1914, owing to the great decrease in the value of the French sardines imported in 1915. During 1916 the importations of sardines fell off over $1,000,000 in value. Nearly 90 per cent of this decrease was caused by the diminished importation of Norwegian sardines. The embargo placed on the exportation of Norwegian sardines by the Government of Norway at the close of the year 1915 and the war conditions in the French sardine industry practically eliminated these goods from this country. The price of foreign sardines resulting from present conditions is practically prohibitive for the domestic market, and only small quantities are available at any price.

TABLE 43.—*Importations of fish packed in oil.*[1]

Country.	Value of imports.						
	1910	1911	1912	1913	1914	1915	1916
France	$1,317,940	$707,644	$495,903	$634,162	$700,984	$446,434	$359,701
Norway	861,944	1,034,946	947,431	1,199,850	1,427,318	1,662,609	741,697
Portugal	346,036	303,565	313,420	477,310	536,451	517,407	334,467
Italy	165,903	191,983	143,541	154,451	255,589	251,383	340,000
Spain	50,943	40,427	39,025	42,262	42,369	23,145	50,573
Total	2,742,766	2,278,585	1,939,320	2,508,035	2,982,711	2,901,978	1,826,438
Total from Europe (including all other countries)	2,982,475	2,533,218	2,079,002	2,659,074	3,178,000	2,996,596	1,911,346

[1] For the years ending June 30, 1910 to 1916. From Annual Reports on Commerce and Navigation of the United States, Bureau of Foreign and Domestic Commerce, U. S. Department of Commerce. Duties under the present tariff are levied on a class of goods packed "in oil." While it is recognized that there are a few articles, such as anchovies, etc., which would be included in the statistics gathered from this source, it is believed that by far the greater part of the values reported is due to oil sardines. The table is given for the purpose of indicating as closely as it is possible to do the business done in foreign sardines in this country.

OUTLOOK FOR THE MAINE SARDINE INDUSTRY.

The volume of foreign sardines handled (Table 43) indicates the possibility of increasing the business in grades of domestic sardines of a quality capable of giving them an entrance to this market and holding the greater portion of it now that the supply of the foreign article is practically cut off (1916). The trade and the consumer should not expect a domestic sardine of exactly the same excellence as the French article, for several factors mitigate against it.

In the first place, the pilchard, from which the French sardine is made, is generally conceded to be the most desirable in point of size, color, texture, and flavor of all the varieties of fish used in the preparation of sardines. Even if it does not possess the very fine shade of flavor characteristic of the French sardine, it is believed that a sardine satisfactory to the most fastidious may be made from the sea herring if the work is properly done. A smoked sardine packed in olive oil has been commercially prepared from the sea herring, and was considered a very superior article.

Another advantage which the French sardine has over the Maine sardine has been aptly expressed by Dr. H. M. Smith, United States Commissioner of Fisheries(27), who states that the unit of measure in the French industry is the individual fish, whereas in this country it is the hogshead. More attention to the details of the packing process on the part of the American canner will aid in eliminating this distinction.

A third point of difference between the two kinds of sardines lies in the fact that the French fish are put up in olive oil, while cottonseed is the oil commonly used in Maine. The consumer who dislikes cottonseed oil will, of course, maintain his preference for the foreign article. As already suggested (p. 66), however, the use of corn oil may improve the standing of some of the better grades of sardines. The high cost of olive oil prevents its being generally employed for this purpose in the United States. In this connection it is interesting to note a provision in the Canadian tariff laws[1] which permits the importation of olive oil, free of duty, when it is to be used in the canning of fishery products. Under this provision olive oil may be entered free under a bond stipulating that it is to be used only in the preservation of fishery products. Such an arrangement in this country might go far toward stimulating the production of an article of quality with which to bid for that portion of the domestic trade formerly occupied by the foreign sardine, and also for the South American trade.

Not only is there an excellent chance to enter the domestic field vacated by the foreign sardines, but the South American markets also offer exceptional opportunities for the introduction of sardines. There are a few features of the South American trade which packers of domestic sardines should bear in mind before attempting to enter this field. The chief consideration is that the sardines must be of good quality, as good as or better than the foreign goods of which these countries are now deprived. The grades of domestic sardines known at the present time as standards will not hold this market.

Another point to be considered is the taste of the people of the South American countries(32). They prefer fish packed in sauces marinase, highly spiced, and are also accustomed to olive oil in the oil sardines. Tomato sauce is a favorite and another is "escabeche," which is made by adding vinegar, pepper, salt, and spices to hot oil in which the fish have been cooked.

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[1] Canada. The Customs Tariff, 1907, p. 31, Schedule A, Item 278. Under provisions of the Canadian war tax, oil covered by this item is now (1916) subject to a duty of 7½ per cent ad valorem. On removal of this tax, oil under this provision will be again free.

Table 44 shows the import values of sardines in the different South American countries for 1910, and, in some instances, for 1912, and lists the principal exporting countries.

TABLE 44.—*Value of sardines imported into South American countries.*

To—	Value.	From—
Argentina	$1,104,898	France and Spain.
Bolivia	[1] 6.80–14	Spain, Portugal, and Italy.
Brazil	[2] 1,267,575	Norway.
Chile	296,485	Spain.
Ecuador	48,553	Germany and Spain.
Panama	30,450	Germany and Great Britain.
Paraguay	....	France, Spain, and Italy.
Peru	102,871	Portugal, Spain, and Germany.
Uruguay	49,546	Spain and France.
Venezuela	252,982	Spain and Germany.

[1] Value per case.

[2] Preserved fish and fish extracts.

According to the United States Department of Commerce(32), Spain and Germany lead in supplying sardines imported into Venezuela, the United States furnishing only $4,427 worth of a total of $252,982. The Spanish sardine is of good quality and reasonable in price. The situation with regard to the possibility of securing a good portion of this trade is well summed up by the following statement(32), calling attention to the inferior quality of the domestic product and the necessity of producing an article appealing to the taste of the people:

> No great increase in exports from the United States to South America of sardines and other fish may be looked for unless the quality of the product can be improved and the tastes of the South Americans considered for fish put down in sauces. The consumption in this line is very large and worthy of study by fish canners.

This publication(32) gives the rates of duty, the details of transportation, shipping, etc., and other valuable information pertaining to sending goods to these countries.

There appears to be no reason, other than a scarcity in the supply of fish and an overwhelming demand from the domestic market, why the American packers of sardines should not obtain their share of the South American trade. This is another irrefutable argument for the improvement of quality.

SUMMARY.

The packers of Maine sardines occupy a very important position in the food industry in their ability to supply a food product which is comparatively cheap and at the same time has a high nutritive value. Careless methods on the part of some packers, due to a desire for quantity production at a sacrifice of quality and to a lack of control over the employees of the plants, have resulted in the appearance on the market of some very low-grade sardines, tending to bring the whole sardine industry into disrepute.

In an effort to assist the packer in improving the character of his output the Bureau of Chemistry conducted an extensive investigation of the packing processes, as a result of which it has been able to make various recommendations to the canners.

The salient points brought out in the course of the experimental work are as follows:

Composition of the fish.—The composition of the sea herring varies during the season, the fat content increasing from July to October. This variation is greater in the case of the smaller than of the larger fish.

Food of the sea herring.—The copepods (red feed) and schizopods (shrimp) constitute the principal food of the sea herring. When gorged with food on being taken from the water the fish are said to be feedy, in which condition they are unfit for packing. The difficulty encountered in the form of feedy fish may be overcome by holding the fish in pounds attached to weirs until they are free from feed, and by cutting and eviscerating the fish before sending them through the packing process.

Swells.—Two organisms, a bacillus apparently identical with Nielsen's *Bacillus Walfischrauschbrand* and *Bacillus B*, a nonspore-bearing pathogenic gas-producing bacterium, are associated with the feed of the small herring, the former being more frequently found with the schizopods and the latter with the copepods. During decomposition of the copepods and schizopods (feed), both ammonia and amines were produced in very large quantities. Growth of the two organisms in pure culture on fish media also produced ammonia and amines. Apparently swells are produced by the action of these organisms, also the condition of the fish known as belly blown.

Transportation of the fish.—It is unnecessary to salt excessively fish which are to be in transit for only a reasonable length of time. Such salting should be done with the idea of saving time in the pickling shed, rather than as a means of preservation, as decomposition, particularly in the viscera and contents, is not completely prevented by the presence of salt. The limit of the time to be consumed in transporting fish in salt, without refrigeration, seems to be from four to six hours. Some method of refrigeration should be installed on all boats used to haul the fish over long distances, thus greatly extending the fishing area and bringing the fish to the canneries in a condition far superior to that of fish carried in salt. The boats, both the refrigerator and the ordinary type, should be provided with small compartments, permitting circulation of cold air, so that the fish are carried in small bulk, thus preventing the rise in temperature which occurs when fish are carried in bulk, as is now customary.

Salting and pickling the fish.—An appreciable amount of nitrogenous matter is extracted from fish held in salt, and an even greater quantity from those held in pickle. To insure a minimum extraction of material, consistent with the proper degree of salting, uneviscerated fish should remain in salt or pickle not more than two hours, while from 15 to 20 minutes is long enough for cut and eviscerated fish to remain in strong pickle. Fish which are excessively salted or are kept in brine an unduly long time lose the characteristics of fresh fish. Sardines with a salt content of 3 per cent were received with the most favor. The greater part of the salt remains in the skin of the fish, which explains why it is so readily lost during the steaming process.

Drying the fish.—More attention should be paid to the drying process than is now customary. Before being packed, from 5 to 8 per cent of the water they contain should be driven from the fish. Either too little or excessive drying ruins the appearance of the pack. An even, thin flaking of the fish, proper control of the volume and temperature of the air in the tunnel dryers, and drying for exactly the requisite period are essential for securing a high-grade product.

Packing the fish.—Special skill and technique are necessary in packing sardines. Great care must be exercised in placing the small fish in the can and also in cleaning the cans. Rough treatment of the filled cans not only tends to disarrange the contents, but may dent the seams, causing leaks.

Oiling.—Three quarts of oil to the case should be added to fat fish, and 3½ quarts to the case for lean fish. Time should be allowed for the absorption of this amount of oil before sealing the cans. Corn oil appears to fulfill all the requirements for a good pack and its flavor does not mask that of the fish. Baked fish packed in corn oil and fish fried in corn oil proved to be superior to fish which were steamed.

Storing the sardines.—The desirability of storing sardines at low, even temperatures was demonstrated by a series of experiments on the freezing and thawing of sardines. Weak solutions of ammonia and amines were found to exert a detinning action on the interior of the cans, which increased on standing. The suggestion that detinning of cans does not occur when fish are skinned before being packed was disproved. During storage the amount of ammonia and amines in canned sardines increases, the extent of the increase depending upon the temperature. Sardines stored at room temperature showed a greater increase in these substances than sardines stored just above freezing. Triamine was found to be the chief constituent of the amine fraction.

Decomposition of fish.—A small amount of ammonia and frequently negligible amounts of amines were found as normal constituents of fresh fish. During decomposition of the fish the quantity of both ammonia and amines increased very rapidly. Greater increases were found in the viscera and contents than in the flesh of the fish. The increase in the amount of ammonia and amines in canned sardines composed of fish which have undergone excessive decomposition indicates that this degree of spoilage can be detected in the packed goods. The determination of these substances, however, is of doubtful value as a means for detecting a less degree of decomposition in fish which have been held in salt or pickle before being packed. Decomposition of the viscera and contents of fish occurs at a more rapid rate than decomposition of the flesh. Fish become belly blown as a result of the extension of the processes of decomposition from the viscera and contents to the belly portion.

Waste.—A great deal of the waste found in the canneries may be eliminated by (*a*) using cans to fit the fish instead of cutting the fish to fit the cans, or trimming the tails of the fish which are a trifle too large for the cans, and cutting the fish as close to the gills as possible, (*b*) flaking so well that 100 per cent of the edible fish on the flakes may be packed, (*c*) preventing the deliberate discarding of fish suitable for packing, and (*d*) enlarging the scope of the pack by preparing kippered herring, Russian sardines, spiced herring, and other similar products. The unavoidable waste may be utilized by (*a*) making sardine paste, deviled sardines, and similar articles from the discarded edible portions of the fish, (*b*) converting the cuttings which can not be used in this way into fish meat meal, after expressing the oil from such residues, and (*c*) converting all residues and wastes that can not be used to better advantage into fish scrap for fertilizing purposes.

Quality and appearance of sardines.—The results of the investigation indicated that the following are the chief factors responsible for low quality: Use of feedy fish rendered unfit by decomposition; excessive salting or pickling; removal of flavor by steaming process; insufficient drying; variation in composition, especially the fat content, of the fish at various times of the year; using inferior oil or oil in insufficient quantities; and permitting the packed goods to become frozen. Careless packing and rough handling at various stages of the process are responsible for poor appearance.

The following suggestions for the improvement of the pack are offered:

1. Accept feedy fish for packing only when they have been impounded for a period of from 12 to 24 hours. When this practice has been widely adopted, it will be wise to keep all fish in pounds or pockets, thus distributing the supply over a longer period and thereby aiding in placing the canneries on a capacity basis.
2. Sort the fish according to size as they reach the cannery.
3. Cut and eviscerate all fish.
4. Establish a proper period for the salting and pickling of fish, both eviscerated and uneviscerated. The salting and pickling treatment of the fish at the cannery as well as the distance they can be carried in salt will then be determined.
5. To insure the highest quality discontinue the steaming process, which causes the loss of a large amount of salt and flavor.
6. Flake the fish by hand or thinly with the flaking machine.
7. Dry the fish to the proper degree before packing them.
8. Pack the fish neatly and attractively in the cans, eliminating all slack packing. A well-packed can of sardines should be full of fish and oil.
9. Handle the packed cans carefully.
10. Establish standard grades for the sardine pack.
11. Maintain a rigid sanitary control of canneries. The law of Maine, which adequately covers this question, should be strictly enforced. The beach surrounding the canneries should be kept free from decomposing fish waste. Under no consideration should swelled cans of sardines be disposed of by being thrown out on the beach. They should be burned. The water supply of all the canneries should be investigated. Whenever a water supply giving evidence of contamination is found, requisite changes should be made.

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